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An Innovative Technique for Water Leak Detection Stemming from Radio Astronomy: A Potential University Technology Transfer

Laxman A. Samtani, Stephen W. Hughes, and Kavoos Mohannak

Abstract—**There have been many documented cases of technology transfer from astronomy to other disciplines such as medicine, for example, a system for diagnosing breast cancer utilising software originally developed to mosaic planetary images. The approach taken in this research will involve using a technology originally developed for radio astronomy to detect water leaks in pipes that are part of water networks in various infrastructure systems. This is innovative research as it involves an interdisciplinary approach to explore a technology and evaluate its commercial potential. Experiments are underway in which signals from an acoustic phased array are amplified and digitized using a multichannel analogue-to-digital (ADC) converter and analysed using a software correlation technique to identify leak signatures.**

Therefore, the chosen technology's commercialisibility will be tested for alternate applications which can be applied to infrastructures such as water networks. In addition, the importance of interdisciplinary research will also be reflected through this research.

I. Introduction

MANY people are still unaware that technology transfer takes place from space technologies to technologies and products for everyday use. Many examples of cross-disciplinary technology transfer can be cited. Baker (2000) has compiled cases of technologies invented by The National Aeronautics and Space Administration (NASA) for space use which have found applications in various areas back on earth. One example which has made a difference in the medical field includes a pump used to deliver insulin to diabetic patients. A company used NASA's micro-engineering technology to manufacture a pump that was small enough to be implanted into the patient, making it more convenient to use and enabling better control of the delivery of medication. Another example is the use of NASA's technology for search and rescue from space using a technology incorporated in a watch. A transmitter fitted in the watch sends signals to the nearest satellite which then directs it to a rescue centre [1].

Some possible applications in Australia that can arise from the transfer of technology from astronomy to medicine, for example, include spectroscopic imaging, signal analysis and submillimeter imaging. This is possible due to the advances in astronomy research in Australia and the presence of organisations such as the Anglo Australian Observatory (AAO), the Australian National Telescope Facility (ATNF) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (http//:www.atnf.csiro.com.au). The topic of interest from the above is signal analysis. There is a need for equipment that can detect very the faint sounds amongst a mixture of noise. Correlators are used to extract weak signals from background noise on the assumption that signals of interest are correlated and noise uncorrelated.

The application chosen is related to water leak detection and this due to the water problems in Australia. There is also the difficulty in detecting leak sounds accurately in plastic pipes as compared to metal pipes. Furthermore, loss of water occurs in distribution systems frequently through loss during flow through pipes from one point to another. The quantity of water loss can depends on factors such as the age and durability of the pipes.

Even though this research involves a business aspect, this paper will aim to showcase the technology and its potential applicability in a new area.

II. Commericialisation and Technology Transfer

Universities have paid much attention to technology commercialisation since the mid-1980s and to exemplify this, in 1979, US universities were granted about 264 patents whereas by 1997, 2436 were granted [2]. This can be attributed to the importance of realising the value of such transfer and that these account for another source of income and contribution to society and industry as well as knowledge spillovers. This is also enforced by the fact that research in universities is no longer constrained to just publishing or academia in general. Commercialising academic research is widely encouraged and is seen as positive. This is true not only because it helps universities get a chance to showcase their research to a wider audience but also because it is an opportunity to obtain industry linkages and additional funding for research which can result in intellectual property (IP) and further benefits. Once commercial potential is recognised, universities encourage industry participation and projects so as to increase funding opportunities as well as input from experienced experts. This however does not

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always result in a successful outcome due to an array of reasons such as the inventor not willing to spend a lot of time on the project or lack of funds in the later stages [3]. The last few decades have seen an increase in contribution to commercial activity from Australian universities. According to statistics, the higher education sector is responsible for more than 25 per cent of all research and development conducted in the last couples of decades [4], [5]. Statistics reveal that in the five year period between 1992 and 1997, Australian universities increased their funding from industry by some $130 million [6, 7]. Additionally, technology transfer from the higher education sector has been economically beneficial and important in the last decade and thus has lead to academic research being commercialised [8], [9]. The literature on the relation of universities and technology transfer provides an insight of the importance of this relationship.

Wang et al. [10] present several key steps that occur in the process of technology transfer (Fig. 1). The figure is a very good and simple representation of the process. It illustrates that the process begins with a research and development (R&D) stage and is followed by organizing the relative IP so as to protect the technology and enhance the opportunity for commercialisation. This is usually followed by the development of a prototype which is then tested and sometimes shown to potential investors. The final stages involve the creation of a product and this is then commercialised through one of many mechanisms such as licensing and spin-offs amongst others.

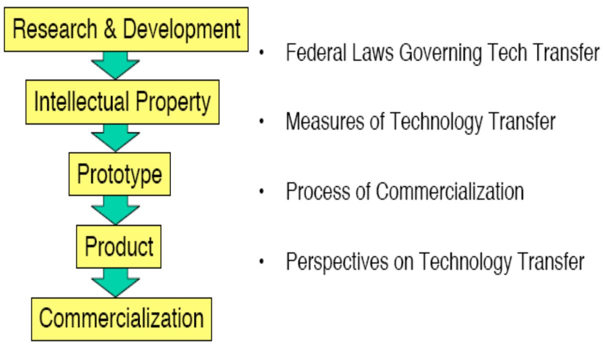

Fig. 1. Steps involved in the technology transfer process (simplified and modified). Source: Wang et al. (2003)

III. CORRELATOR TECHNONOLOGY

This section will elaborate on the original technology and the application that is being investigated.

The Australia Telescope Compact Array (ATCA) at the Paul Wild Observatory, 23 km west of the town of Narribri in NSW, Autstralia (http//:www.narribri.atnf.csiro.com.au) is composed of six 22m dishes on a railway track 6km in length. Signals are collected at the dishes and transferred to a correlator room in the control building. Time tag information is used to match the signals prior to processing by the hardware correlator [11] (Fig. 2).

Fig. 2. Hardware correlators at the ATNF, Narrabri, NSW, Australia.

Swinburne University of Technology (Melbourne, Victoria, Australia) have developed a software correlator that performs the same function as the hardware correlator situated at the ATCA which is operated by The ATNF (a division of CSIRO). In the research described in this paper, the software correlator software is used to analyse signals obtained from an acoustic phased array. This technology could be utilised for enhancing the sound created by leaks in water pipes which are not normally audible otherwise. This can possibly be achieved by using multiple microphones positioned strategically so as to pick up the signal of interest and using the phase lags, triangulating into the source of the sound. This will result not only in identifying a leak but also where the leak is located.

As mentioned above, conventionally, the hardware version has been utilised in astronomy but in this case the software version will be used and this has several advantages over the hardware version. These include it being more flexible and rapid and eventually cheaper to use. The decrease in the cost of computing has made software correlators more attractive. The software version is also more compatible and expandable and has the possibility of being modified and further developed (Deller, 2006) (Fig. 3 for software version).

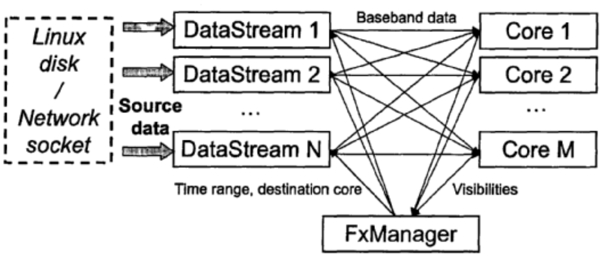

Fig. 3. Overview of the software correlator architecture [12].

IV. MATERIALS AND METHODS

The first phase consisted of setting up the necessary equipment for collection of data. A 4-channel Analogue-to-Digital Converter (ADC) (NI 9215) capable of digitising signals at a rate of up to 100 KHz/channel has been acquired from National Instruments. A particular advantage of this ADC is that signal channels can be acquired simultaneously. This enables precise correlation of the signals and also enables the direction of a sound source to be determined. The ADC is interfaced to four microphones via four audio amplifiers. The basic idea is to get water flowing through a pipe and create leaks that can be detected using a simulated model in the laboratory.

A software called LabView (developed by National Instruments) (http//:www.nationalinstruments.com) will assist with data collection. A water leak model has been constructed in the laboratory and the acoustic signal generated acquired using one, two, three and four microphones. A key question is whether two or more microphones are better than one, i.e. the detection threshold is lower. Also, the accuracy of the four microphone phased array in determining leak direction relative to the array will be investigated. The sensitivity of the system will be assessed by varying the distance between the phased array and leak. Frequency analysis of the signal will also be performed on the signal using the Fast Fourier and Wavelet Transforms. Therefore, critical variables involved here are distance and frequency. Fig. 4 illustrates the setup. The data collected will then be processed using the software correlator version.

The tests were initially carried out with one microphone, then two and the results run through the software to find out if the sound of interest was being picked up. At this point the sound was just click of fingers and whistling. Once these tests were confirmed then a circuit was built consisting of four microphones each having the same component but these details cannot be revealed completed due to confidentiality. The circuit board was put in a metal box so as to minimise noise.

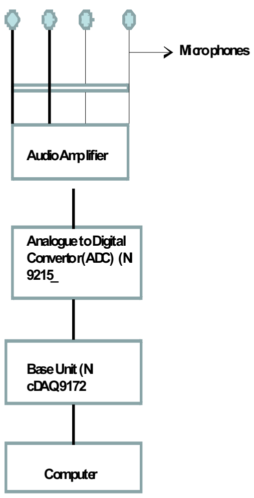

Fig. 4. Set up for data collection

The ongoing tests will involve experiments with PVC and metal pipes on three levels, no flowing water (control), flowing water and flowing water with leaks. This is done so as to compare the results to verify if a distinct sound is produced by the leak and therefore if it can be detected.

Further tests will also involve using accelerometers in addition to microphones to check for the possibility of detecting differences in vibrations caused by a leak as well as if at all this would be possible in the case of plastic pipes.

V. FUTURE RESEARCH

In addition to one of the many possible applications being investigated in this research, in this instance, the possibility of a new application for water leak detection, an interesting future application worth investigating would be the medical application of the correlator technology to detect minute electrical and/or magnetic signals within the human body.

In conclusion, it might be possible that the technology in question in turn can help contribute to water infrastructure systems where the technology can be used to minimise leaks, optimise the life of the asset and therefore, enhance the infrastructure system.

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