Chapter 61
Designing a Compact Wireless Network Based Device-Free Passive Localisation System for Indoor Environments

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ABSTRACT

Determining the location of individuals within indoor locations can be useful in various scenarios including security, gaming and ambient assisted living for the elderly. Healthcare services globally are seeking to allow people to stay in their familiar home environments longer due to the multitude of benefits associated with living in non-clinical environments and technologies to determine an individual's movements are key to ensuring that home emergencies are detected through lack of movement can be responded to promptly. This paper proposes a device-free localisation (DFL) system which would enable the individual to proceed with normal daily activities without the concern of having to wear a traceable device. The principle behind this is that the human body absorbs/reflects the radio signal being transmitted from a transmitter to one or more receiving stations. The proposed system design procedure facilitates the use of a minimum number of wireless nodes with the help of a principle component analysis (PCA) based intelligent signal processing technique. Results demonstrate that human detection and tracking are possible to within 1m resolution with a minimal hardware infrastructure.

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1. INTRODUCTION

In the field of ambient assisted living for the elderly, a new technology is proposed that utilises a home wireless network to possess tracking abilities that would enable in-home activity monitoring. Home activity monitoring is a means by which a carer may give assistance to an individual remotely at a time that is convenient to them. This promotes the current desire to let the aging population remain within their home as they get older and improve their quality of life (TRIL, 2010; Mann, 2005). Determining the location or activity of an individual over time can aid in providing effective carer assistance without the overhead of regular home visits (Srivastava, 2009). Apart from the obvious emergency services applications, the context information provided may be used to monitor for irregular sleeping patterns, dietary habits, social interactions and mobility. Carers can utilise this information to provide the best care on an individual basis. Using Radio Frequency (RF) for this purpose out performs visible light (video cameras) and Infra-red (PIR sensors) as it is both non-invasive and can penetrate non-metal walls within the home (Rogers & Brown, 1997). PIR sensors also have the limitation where they only detect presence whilst there is movement. RF energy can detect presence whilst the human body is perfectly still.

There are various signal based location determination technologies that may be used for assisted living including; GPS (Vance et al., 2007; Carmien, 2003), Wi-Fi (Kelly et al., 2008, Cellular (Niemela et al., 2007) and Ultra-Wide Band (UWB). Currently, Wi-Fi is the most popular technique for in-home use as Cellular does not have a good resolution (Hightower & Borriello, 2002) and GPS generally does not operate within buildings (Shuangquan et al., 2006). UWB on the other hand can be quite effective though it is costly to implement (Yanying et al., 2009). Currently, one of the major limitations is that the user must carry a propriety device in order to be located or tracked. Such active-device indoor localisation approaches are inefficient in terms of the quality of data received and the expense of wearable device units as the user often either mislays the device, accidentally breaks it or forgets to wear it on a daily basis (Williams et al., 2010; Naditz, 2009).

This paper proposes a device-free technique for localisation which will enable the user to proceed with their daily activities without the requirement of having to wear a traceable device. The main principle behind this device-free strategy is the absorption phenomenon of the Received Signal Strength (RSS) of transmitted wireless signals as the human body crosses a transmission-receiver path (Lin et al, 2008). A number of techniques in the field of Device-free Localisation (DFL) have been proposed recently (Wilson & Patwari, 2009; Dian & Lional, 2012; Youssef et al., 2007; Patwari & Wilson, 2010; Mah, 2012) investigating technologies such as UWB, RADAR and MIMO for its use. In (Wilson & Patwari, 2009), localisation is reported to have achieved an accuracy of less than 1m though the hardware infrastructure consists of multiple nodes in excess of 20 to cover a small area. The techniques proposed in this paper aim to provide faster and more accurate and economical localisation compared to those previously reported using a minimal infrastructure.

In Section 2 of the paper an outline on the proof of concept is provided and Section 3 provides an analysis on selecting appropriate transmitter-receiver configurations. Section 4 details the novel localisation algorithms investigated and Section 5-7 present data analysis and experimental results in relation to localisation for an example indoor environment under different network configurations. Finally, Section 8 presents a concluding summary.