Summer 6-15-2016

EXAMINING DIGITAL ASSISTED LIVING: TOWARDS A CASE STUDY OF SMART HOMES FOR THE ELDERLY

Niroshinie Fernando
Deakin University, niroshinie.fernando@deakin.edu.au

Felix Ter Chian Tan
University of New South Wales, f.tan@unsw.edu.au

Rajesh Vasa
Deakin University, rajesh.vasa@deakin.edu.au

Kon Mouzaki
Deakin University, kon.mouzakis@deakin.edu.au

Ian Aitken
Samsung Australia, i.aitken@samsung.com

EXAMINING DIGITAL ASSISTED LIVING: TOWARDS A CASE STUDY OF SMART HOMES FOR THE ELDERLY

Research in Progress

Fernando, Niroshinie, Deakin University, Australia, niroshinie.fernando@deakin.edu.au

Tan, Felix, University of New South Wales, Australia, f.tan@unsw.edu.au

Vasa, Rajesh, Deakin University, Australia, rajesh.vasa@deakin.edu.au

Mouzakis, Kon, Deakin University, Australia, kon.mouzakis@deakin.edu.au

Aitken, Ian, Samsung Australia, i.aitken@samsung.com

Abstract

Actualising assisted living for increasing aging populations, who want to continue living at home, is a significant challenge in many countries. IT enabled assistive systems can address this challenge by providing services such as home automation, providing security, identifying potential health risks, and monitoring environmental hazards. However, current solutions often undervalue the effects of user perceptions of, and interactions with, technology when deploying such systems. As a result, current systems do not accurately represent the goals of the elderly users, who often do not identify the potential uses of such systems and perceive them to be too complex, invasive and/or irrelevant. Consequently such solutions frequently fail to be utilised to their full potential, thus deterring the successful adoption of technology for assisted living. This study aims to better understand the role of IT in assisted living by examining case studies in the literature through an affordance lens. We identify IT affordances of such digital assisted living systems based on the existing affordances of the 'home environment', and explore inter-relations between the IT affordances. These findings will form the theoretical foundations of a smart home project currently under development, which aims to help people to remain healthy and safe in their own home as they grow older. The initial iteration of this technology is planned to be trialled in homes of elderly users shortly, and will provide the case study for our future work.

Keywords: smart homes, aged care, IT affordances, digital assisted living.

1 Introduction

Many nations across the world are experiencing the social and economic impact of aging populations. It is projected that the global old-age support ratio (average number of persons between 15-64 years to support each older person) will decline to four by 2050 (United Nations, 2013). This has amplified the interest in technologies that can be used to support the requirements of aged populations and aged care services. For example, a main priority of the elderly demographic is continuing to live at one's home and maintaining one's independence (Robert, Lo, Secombe, & Wong, 2009; Van Hoof, Kort, Rutten, & Duijnstee, 2011). However, concerns about security, falling or other emergencies and health issues pose significant obstructions to this.

IT-enabled assisted living can address these concerns by providing various automated services to maintain elderly residents' independence while living in their own home. The term 'assisted living'(AL) broadly refers to the provision of support services (skilled nursing/facilitating daily activities) in a residential setting (private dwelling/retirement community) with varying degrees of privacy and autonomy (Chapin & Dobbs-Kepper, 2001; Zimmerman, 2001; Kane & Wilson, 1993; Mitchell & Kemp, 2000). Employing IT to support AL can lessen the stress on aged-care facilities and also fulfil the elderly's desire to continue to live at their home. However, case studies in the literature show that, despite increasing attempts at actualising such IT systems, there are many socio-technical barriers in the adoption of this technology.

According to case studies conducted in a retirement community in Missouri, USA (Demiris, et al., 2004; Demiris G. , Hensel, Skubic, & Rantz, 2008), despite concerns such as obtrusiveness, lack of human contact, and lack of user-friendliness, elderly participants showed positive attitude towards several IT-enabled AL applications. However, they focused only on the features to detect emergency situations but not on other applications such as early detection of potential health problems. This corresponds to the findings in (Robert, Lo, Secombe, & Wong, 2009) where the elderly participants regarded AL technology as identical to conventional emergency response systems. This suggests that current systems have failed to be accurately perceived by the users. Another recurring theme is the view of IT enabled AL as irrelevant. Studies suggest that this may be caused by the fear of being too dependent on technology and stigma of been viewed as disabled/dependant (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, Social barriers to the adoption of smart homes, 2013; Portet, Vacher, Golanski, Roux, & Meillon, 2013; Peek, Wouters, Hoof, Luijkx, Boeije, & Vrijhoe, 2014). Other key concerns among the elderly regarding adoption include; cost (Demiris, et al., 2004; Robert, Lo, Secombe, & Wong, 2009; Peek, Wouters, Hoof, Luijkx, Boeije, & Vrijhoe, 2014) integration issues with existing home and services, obtrusiveness (Van Hoof, Kort, Rutten, & Duijnstee, 2011), loss of control and reliability (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, Social barriers to the adoption of smart homes, 2013). This suggests that current designers have no cohesive theoretical foundation from which to derive what services are required by the potential users, how they perceive IT enabled AL, how the technology needs to be designed for their services to be accurately visible to and be actualised.

Given the above, the research question investigated in this paper is: How can IT enable assisted living? To address this question, we examine case studies of smart homes as examples of IT enabled AL for elderly users, and extend the current affordance theory (Gibson, 1977) to accommodate IT artefacts in such systems. We introduce the term 'digital assisted living' and conceptualise it in terms of its technical affordances, which are derived from the existing affordances of the 'home environment'. In developing this model, we establish a better understanding of IT-enabled AL. For practitioners this study reveals factors to consider in order for designing solutions that can lead to wide-scale adoption.
After a brief review of the literature in Section 2, Section 3 describes the research method employed in this study. The preliminary findings in the form of IT affordances of smart home and their interrelations are discussed in Section 4. Section 5 summarises the research contributions and highlights areas for future work using results from the smart home project that is under development, as a case study.

2 Literature Background

2.1 Digital Assisted Living

Digital Assisted Living (DAL) can be defined as the provision of IT enabled assisted living services in a residence, with the goal of enabling independent living for people requiring assistance in their activities of daily living. Examples for such DAL services can include automatically controlling the environment (e.g. A/C), reminding them to take their medicine and providing some guidance on water intake on a hot day. Such an intelligent environment can also identify potential security threats (Demiris G. , Hensel, Skubic, & Rantz, 2008) and anomalous behaviour of the residents that could imply a critical health risk (Suryadevara, Mukhopadhyay¸S.C., Wang, & Rayudu, 2013). Therefore, DAL is a specialisation of the 'smart home' concept and arises from the intersection between smart homes and AL, as illustrated in Figure 1.

The term 'smart home', or 'smart house' was first used in 1984 by American Association of House Builders (Harper, 2003) and has been defined as "a residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond" (Harper, 2003).

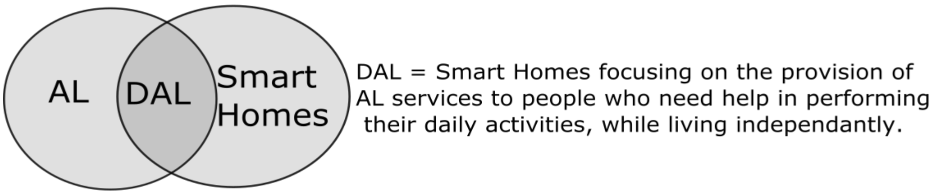

Figure 1: DAL as a specialisation of Smart Homes that offer AL services

The initial focus of the smart home movement was on enabling intelligent environments for the wider community in general. However, in recent times, a number of studies have explored employing this concept to provide various assistive services to elderly people living at home. In this paper, we examine the phenomenon of DAL via case studies of smart homes providing assistive services to elderly people living independently.

Examples for such assistive services include; promoting good health (Rialle, Duchene, Noury, Bajolle, & Demongeot, 2002. ; Suryadevara, Mukhopadhyay¸S.C., Wang, & Rayudu, 2013; Tang & Venables, 2000), Supporting social interaction and offering cognitive assistance (hydration/prescription reminders, lost key locator) (Demiris & Hensel, Technologies for an aging society: a systematic review of smart home applications, 2008), saving energy and operation costs (Pedrasa, Spooner, & and MacGill, 2010; Santacana, Rackliffe, Tang, & and Feng, 2010; Wissner, 2011), Home automation (Lien, Bai, & Lin, 2007; Portet, Vacher, Golanski, Roux, & Meillon, 2013; Zamora-Izquierdo, Santa, & Gomez-Skarmeta, 2010), and Security (human and environmental threats) (Demiris G. , Hensel, Skubic, & Rantz, 2008; Helal, Mann, El-Zabadani, King, Kaddoura, & Jansen, 2005; Snoonian, 2003).

Although all of these services address valid concerns, there is lack of research on the underlying human requirements and perceptions that relate to each of these. As a result, even if the technical solutions are accurate, they are often not the correct manifestations of the underlying user requirements. For example, some elderly users in the case study discussed in (Portet, Vacher, Golanski, Roux, & Meillon, 2013), were hesitant to use automated functions (such as opening blinds in the morning) because they feared that automating certain aspects of their daily routines would leave them with nothing to do, and make them feel useless. In this case, the system's goal (convenience) was contradictory to the users' goal (independence).

It is important to recognise that a 'home' is not defined by geographical boundaries it occupies or its functions, but by meanings given to those boundaries and functions, from the activities and relationships that take place in it (Mallett, 2004; Douglas, 1991; Easthope, 2004). Therefore, a technical solution that aims to enhance one's 'home' also needs to embody its primary meaning, instead of as a list of surface functions viewed in isolation.

DAL enabled homes can be viewed as inter-related networks of actors (occupants, health care providers, care givers) who interact with each other and the IT artefact (the technical solution), where the interactions lead to conflicting (eg: safety vs privacy, care vs autonomy) and complementary (eg: customisation and convenience) tensions. Furthermore, advancements in IoT will result in numerous and heterogeneous smart consumer electronic devices offering services for DAL environments. This will lead to to increased evolution while raising concerns for stability. In this context, we view a DAL enabled home as an ecosystem and use affordances (used in the study of ecosystems) to investigate the phenomenon of DAL.

2.2 IT Affordances

The concept of affordances was first introduced by the psychologist J.J. Gibson (The theory of affordances, 1977) in ecological psychology, and discusses the idea of the actor-environment mutuality. Affordances are possibilities for user actions and can exist in the environment regardless of being recognised by the user or not.

Identifying the IT affordances in a smart home is the first step in successful actualisation and adoption. However, literature shows that 'home' is a phenomenon with social, psychological and emotive connotations for individuals and groups. For many, 'home' is a refuge, removed from public scrutiny and surveillance (Mallett, 2004), and typically a possessed space. Therefore, due to its sensitive nature, actualizing the IT affordances of a 'smart home' poses more challenges than other smart environments. We hypothesise that if a smart home is to be successful, its IT affordances need to enhance the goals of the home, without taking away any of the existing affordances (or be perceived as doing so). Peter Somerville identifies the seven key signifiers afforded by the home as shelter, hearth, heart, privacy, roots, abode and (possibly) paradise (Somerville, 1992). We identify these signifiers as the underlying affordances of the home, as described in Table 1 and use them to derive the IT affordances of the smart home.

Signifier	Description
Shelter	Protects the user/s from the elements and intruders
Hearth	Provides a warm and cosy environment for the inhabitants to relax, be healthy & engage in hobbies.
Heart	Provides emotional wellbeing as well as being a site of consistency
Privacy	Gives its occupant/s power to control their own boundaries (such as who is allowed in the home), and freedom from surveillance and external role expectations
Roots	The occupant/s sense of self and identity, which is bound to one's home.
Abode	The minimal definition of home, merely as a place to stay. (eg: sleep, eat, keep possessions)
Paradise	A unique mix of the first six affordances of an 'ideal home' that exists in the mind of each individual

Table 1: Seven signifiers and underlying affordances of the home

3 Research Method

The focus of our study is an emerging phenomenon of DAL that has only recently attracted the attention of IS researchers. Recognising that DAL is a complex and multi-dimensional phenomenon, we employ the case study research methodology, which is particularly suitable for such an exploratory research effort (Siggelkow, 2007), and allows us to identify the role of IT in assisted living.

We first applied the existing research on home, to identify the functions afforded by the 'home' environment. We then studied the smart home literature to map the technical functions afforded by smart homes to the underlying signifiers. This mapping was used to derive the IT affordances of the smart home. Before introducing our case study, we first examined five cases of published case studies on smart homes (please see Table 2), using IT affordances as our theoretical lens.

Case study	Objective of case study
15 residents from TigerPlace, a retirement community in USA (Demiris, et al., 2004; Demiris G. , Hensel, Skubic, & Rantz, 2008)	investigate the perceptions and expectations of elderly residents about smart home technology
13 residents living independently in private dwellings randomly selected from Australia (Robert, Lo, Secombe, & Wong, 2009)	investigate the perceptions and concerns of elderly residents about smart home technology
18 community-dwelling residents living in The Netherlands using the Unattended Autonomous Surveillance smart home system (Van Hoof, Kort, Rutten, & Duijnstee, 2011)	investigate the needs and motives of elderly residents on ageing-in-place, and how the system contributed to aspects of ageing-in-place

8 residents using the DOMUS smart home system with voice command in France (Portet, Vacher, Golanski, Roux, & Meillon, 2013)	assess the acceptance and fear of using the smart home system
11 community-dwelling residents living in either independent living or assisted living facilities in the USA (Courtney, Demiris, Rantz, & Skubic, 2008)	investigate the factors that influence older adults living in independent and assisted living dwellings to adopt smart home technology

Table 2: Case studies on elderly residents using smart homes

This allowed new and in-depth findings on the inter-relations and conflicts between the identified IT affordances to emerge. The main case selection criteria for the five case studies was that the participants were at least over 65 years of age, and that they were either living independently in private dwellings or in retirement communities.

These initial findings will form the theoretical foundations of the case study of our smart home project which is a research initiative focused on devising ambient smart homes to enable older people to continue to live in their own homes. The technology differentiates itself due to use of low-cost sensors, having a platform that allows developers to build apps and has built-in deep analytics. The initial trials will take place in a number of private homes in Australia, and will provide the data for the case study for our future work. Figure 2 introduces the case study and illustrates the research framing.

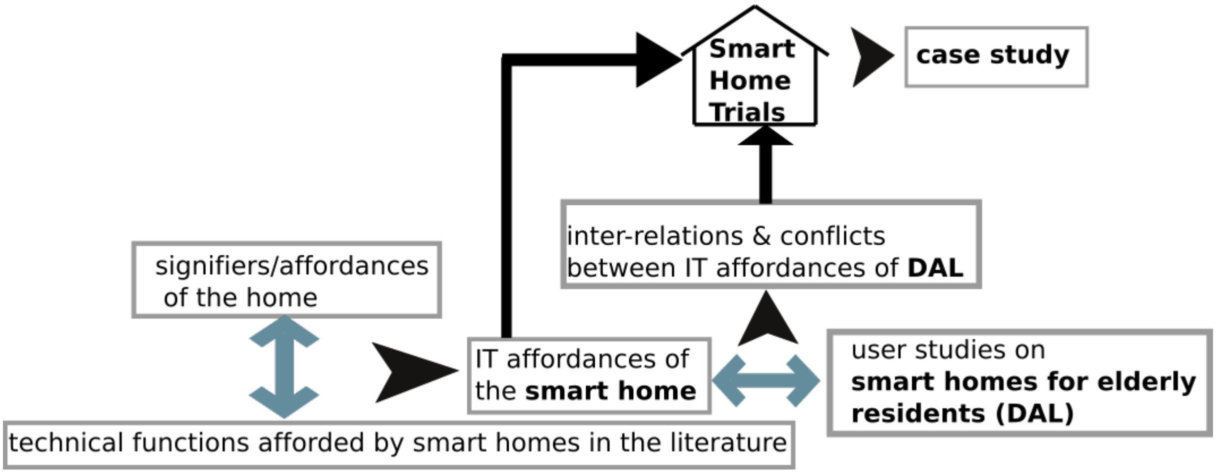

Figure 2: Investigating the role of IT in Digital Assisted Living using smart homes through case study

We base the construction of our conceptual model on the template proposed by Strong et.al (Strong, et al., 2014) for developing affordance-actualization theories, which primarily addresses the following: affordances in an organisational (in this case, the smart home) context, inter-related affordances and the process of affordance actualization. In this paper, we only focus on the identification of IT affordances in a DAL context, and examining the relevant inter-related affordances.

4 Preliminarily Findings

By synthesising signifiers and the technical functions of smart homes in related research, we have identified twelve IT affordances of the smart home as illustrated in Figure 3. As can be seen in Figure 3, the IT affordance of *detect anomalies* is derived from the signifier 'shelter'. This IT affordance makes it possible to detect patterns and identify unexpected events (Jakkula & Cook, 2011) such as intruders or health emergencies, which can then be used to generate alarms or inform third parties such as security or care givers. As indicated by the signifier 'hearth', occupants prefer their home to be a hassle-free and relaxing environment. This gives rise to the IT affordances of *Use heterogeneous devices* and *remotely monitor home and automate tasks.* Smart home devices that support different specifications and standards make it difficult to manage devices from heterogeneous vendors and create isolated islands of functionality (Edwards & Grinter, 2001), inconveniencing the user, and remote monitoring applications give users the ability to interact with the home even when they are away, while automating mundane tasks can save time and costs.

As the aforementioned IT affordances promote physical wellbeing, the IT affordances of *non-intrusive monitoring, easily use system* and *interact with external entities* promote emotional wellbeing, and are derived from the home signifier 'heart'. The need for non-intrusiveness has been stressed in surveys, which reveal that many people wish for passive monitoring instead of intrusive methods such as wearable devices (Portet, Vacher, Golanski, Roux, & Meillon, 2013). *Easily use system* relates to the usability of the system from an end user's perspective. Smart home interfaces need to facilitate easy to learn, simple interactions with technology that is targeted to the task (Kim, Oh, Cho, Lee, & Kim, 2012). Domain knowledge is also necessary so that methods of interfacing can be customised to suit the specific needs of the primary target demographic. Moreover, by enabling interactions with external entities, users can interact with carers, loved ones and third party services such as supermarkets (Kirkham, Armstrong, Karim, & Jiang, 2014).

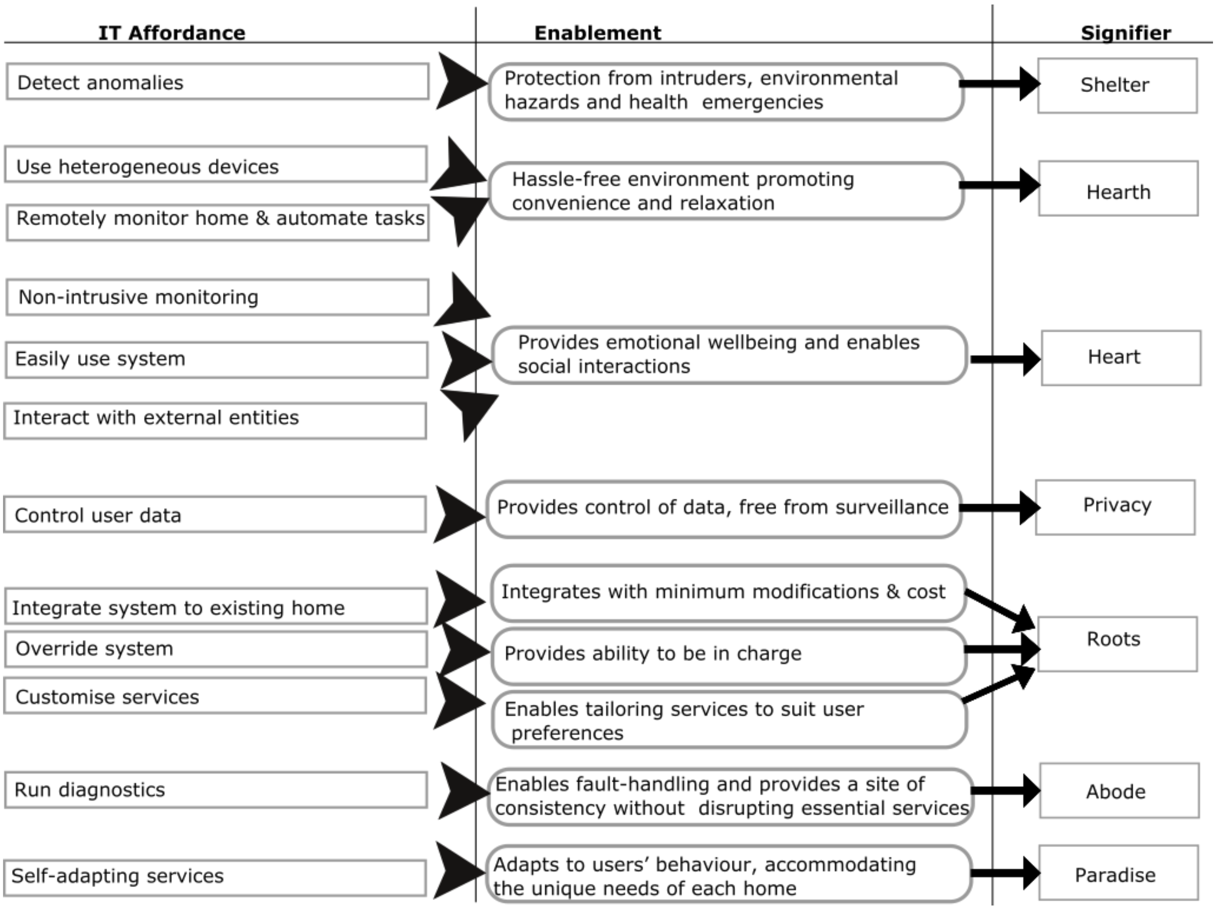

Figure 3: Derivation of IT affordances from home signifiers and their IT functions

The IT affordance of *control user data* is an extension of the signifier 'privacy', and relates to safeguarding the sensitive information that is generated in a smart home from sensor readings. Having their intimate details accessed by a third party will cause distress to most people, and can also pose hazards such as possible break-ins, defamation, and embarrassment. Therefore, it is vital that the users have control of their own data.

The signifier 'roots' is linked with the three IT affordances of *customise services* and *integrate system to existing home & override system*. 'Roots' signify the occupant's sense of identity that is bound to his/her home. Therefore giving the users options to customise various aspects of smart home technology as a way of expressing their identities is important, as well as to integrate the system to existing home environment with fewest modifications possible (Barlow & Gann, 1998) and the ability to be in control of the technology.

Faults in smart homes can occur due to a number of reasons; sensor failure, network failure or processing unit failure. In particular, for services related to health care, the reliability of services, and fault-handling will be of paramount importance. This aspect gives rise to the IT affordance of *'run diagnostics'*, which enables the user to identify potential system failures. This is linked with the signifier 'abode', which refers to the occupant's minimum expectation of home as a reliable site.

Finally, the last IT affordance of *self-adapting services* is linked with the distinct mix of priorities and preferences of the aforementioned nine IT affordances that is unique to each individual, and is expressed in the signifier 'paradise'. Also, humans tend to alter their habits and activities (Rashidi & Cook, 2009) over time. Hence, an ideal smart home needs to be able adapt to user behaviours and events, supporting diversity and evolution of choices.

4.1 Inter-relations between Smart Home IT affordances

We now discuss the inter-play of the identified IT affordances in smart homes by examining five case studies involving elderly residents. Although some IT affordances can complement each other, others are driven by contrasting needs and hence, can conflict with each other, as summarised in Table 3.

IT affordance	Complementary	Conflicting
Detect anomalies	Self-adapting services, Interact with external entities	Control user data, Non-Intrusive monitoring
Use heterogeneous devices	Integrate system to existing home, Run diagnostics	-
Remotely monitor home and automate tasks	Self-adapting services	Override system
Non-Intrusive monitoring	Control user data	Detect anomalies
Interact with external entities	Detect anomalies	Control user data
Easily use system	Customise services	-
Control user data	Non-Intrusive monitoring	Detect anomalies, Interact with external entities
Customise services	Self-adapting services, Easily use system	Run diagnostics
Integrate system to existing home	Use heterogeneous devices, Run diagnostics	-
Override system	Run diagnostics	Remotely monitor home and automate tasks
Run diagnostics	Use heterogeneous devices, Override system, Integrate system to existing home	-
Self-adapting services	Detect anomalies, Remotely monitor home and automate tasks , Customise services, Easily use system	-

Table 3: Inter-related IT affordances of the smart home

The IT affordance of 'detect anomalies' is complemented by 'self-adapting services' because both concern identifying patterns and learning from users. In many cases, when anomalies (eg: occupant falls sick, intruder) are detected, external parties such as carers, emergency contacts or security services need to be contacted. Thus, it is also complemented by the affordance 'interact with external entities'. However, 'detect anomalies' can conflict with 'control user data' and 'non-intrusive monitoring' (which complement each other) because it requires the collection and processing of sensor data, and certain sensing methods can be regarded as intrusive by users. For example, in case studies (Demiris G. , Hensel, Skubic, & Rantz, 2008) and (Portet, Vacher, Golanski, Roux, & Meillon, 2013) most users felt the video sensor was too intrusive and violated their privacy even though it was useful to detect emergencies. The IT affordances of 'use heterogeneous devices', ' integrate system to existing home' , 'override system' and 'run diagnostics' are complementary to each other because they promote the incorporation of technology in to the existing environment with minimal disturbances and malfunctions while providing the users with autonomy to control their surroundings. If and when a user is notified of a potential system failure (eg: a faulty sensor), then he/she can either disregard or overrule the services relating to the faulty component. The importance of these aforementioned four affordances were evident in case studies where users preferred the least amount of alterations and expense to their houses to accommodate technology (Van Hoof, Kort, Rutten, & Duijnstee, 2011; Demiris, et al., 2004; Robert, Lo, Secombe, & Wong, 2009), and were worried about technology failing at critical times and incorrect diagnosis (Robert, Lo, Secombe, & Wong, 2009; Portet, Vacher, Golanski, Roux, & Meillon, 2013). The IT affordance 'Remotely monitor home and automate tasks' can conflict with the IT affordance of 'override system' because the users' desire to be in control can conflict with automating tasks. This was evident in (Portet, Vacher, Golanski, Roux, & Meillon, 2013) where some automated services were rejected as the elderly users did not like to be too dependent on the system which might lead to inactivity. However, the acceptance of automated services was varied among the participants, suggesting that it can depend on user priorities (be in control vs convenience) and limitations at that particular age (e.g.: cognitive and sensory impairments). Hence, it can be complemented by 'self-adapting services' by adapting the system automatically to suit changing needs of the occupants. The ability to provide interactions with external entities including loved ones and health care workers was desired in the case studies (Van Hoof, Kort, Rutten, & Duijnstee, 2011). However this IT affordance can conflict with 'control user data' since it can entail the sharing of personal data such as a shared calendar with social activities and medical data (Portet, Vacher, Golanski, Roux, & Meillon, 2013; Robert, Lo, Secombe, & Wong, 2009). The IT affordance of 'customise services' can be complemented by the two affordances 'self-adapting services' and 'easily use system' since they aim to tailor smart home services to suit users' needs and desires in a way that is satisfactory and/or pleasurable to the user (Courtney, Demiris, Rantz, & Skubic, 2008).

5 Research Contributions and Future Work

Our study shows that DAL can be represented in the form of its IT affordances. The first contribution of this work is the derivation of IT affordances of a DAL environment from the affordances of the home. However these IT affordances are inter-related, and the second contribution is a discussion of how they enhance as well as contradict each other. The degree of actualisation of each IT affordance in DALs and the balance between conflicting IT affordances will depend on the preferences, capabilities and needs of each user, which can change as time passes. Hence DALs need to offer choice and be able to evolve with changing patterns of each home. To this end, we propose the twelfth IT affordance, namely self-adapting services, as a continuous amalgamation of the first eleven IT affordances.

These preliminary findings will be used in forming a comprehensive theoretical model of DAL, in collaboration with our smart home project. The current services provided are in line with the IT affordances discussed in this work, and the initial trial have been designed to test the hypothesis that the current services provide some of the aforementioned IT affordances, thereby enhancing the affordances of the home. The initial prototype will be deployed in private dwellings, where the participants will be living independently and the key focus will be on users aged 55 and above. The system will record sensor data such as user motion and air temperature and the participants will be interviewed before, during and after the trial to gather their experience using the smart home. The elderly's carers (family/emergency contacts) will also be interviewed to gain an understanding of their experience with the smart home as an external party. This will further clarify the research focus by modelling the phenomenon in two layers, with one layer representing the elderly and the other representing the external entities.

Data collected from the project's trials will form our case study for future work that will investigate the process of actualising the IT affordances of DAL environments.

References

Augusto, J. C. & McCullagh, P., 2007. Ambient intelligence: Concepts and applications. *Computer Science and Information Systems,* pp. 1-27.

Augusto, J. C., Nakashima, H. & Aghajan, H., 2010. Ambient intelligence and smart environments: A state of the art. *Handbook of ambient intelligence and smart environments,* p. 3–31.

Balta-Ozkan, N., Davidson, R., Bicket, M. & Whitmarsh, L., 2013. Social barriers to the adoption of smart homes. *Energy Policy,* Osa/vuosikerta 63, pp. 363-374.

Balta-Ozkan, N., Davidson, R., Bicket, M. & Whitmarsh, L., 2013. The development of smart homes market in the UK. *Energy,* Osa/vuosikerta 60, pp. 361-372.

Barlow, J. & Gann, D., 1998. *A changing sense of place: are integrated IT systems reshaping the home?.* s.l.:University of Sussex, SPRU.

Chapin, R. & Dobbs-Kepper, D., 2001. Aging in Place in Assisted Living Philosophy Versus Policy. *The Gerontologist ,* 41(1), pp. 43-50.

Cook, D. J., Augusto, J. C. & Jakkula, V. R., 2009. Review: Ambient intelligence: Technologies, applications, and opportunities. *Pervasive Mobile Computing,* 5(4), p. 277–298.

Courtney, K. L., Demiris, G., Rantz, M. & Skubic, M., 2008. Needing smart home technologies: the perspectives of older adults in continuing care retirement communities. *Informatics in primary care,* 16(3), pp. 195-201.

Das, S. K. ym., 2002. The role of prediction algorithms in the mavhome smart home architecture. *Wireless Communications, IEEE,* 9(6), p. 77–84.

Demiris, G. & Hensel, B. K., 2008. Technologies for an aging society: a systematic review of smart home applications. *Yearbook Medical Informatics,* Osa/vuosikerta 3, p. 33–40.

Demiris, G., Hensel, B. K., Skubic, M. & Rantz, M., 2008. Senior residents' perceived need of and preferences for "smart home" sensor technologies. *International Journal of Technology Assessment in Health Care,* 24(01), pp. 120-124.

Demiris, G. ym., 2004. Older adults' attitudes towards and perceptions of 'smart home' technologies: a pilot study. *Informatics for Health and Social Care,* Osa/vuosikerta 29, pp. 87-94.

Douglas, M., 1991. The idea of a home: a kind of space. *Social research,* p. 287–307.

Easthope, H., 2004. A place called home. *Housing, theory and society,* 21(3), p. 128–138.

Edwards, W. K. & Grinter, R. E., 2001. *At home with ubiquitous computing: Seven challenges.* s.l., Ubicomp 2001: Ubiquitous Computing, Springer Berlin Heidelberg, pp. 256-272.

Friedewald, M. ym., 2005. Perspectives of ambient intelligence in the home environment. *Telematics and Informatics,* 22(3), p. 221 – 238.

Gibson, J. J., 1977. *The theory of affordances.* s.l.:s.n.

Harper, R., 2003. *Inside the smart home.* s.l.:Springer Science & Business Media.

Helal, S. ym., 2005. The gator tech smart house: A programmable pervasive space. *Computer,* 38(3), p. 50–60.

Jahn, M. ym., 2010. *The energy aware smart home.* s.l., International Conference on Future Information Technology (FutureTech).

Jakkula, V. R. & Cook, D. J., 2011. Detecting Anomalous Sensor Events in Smart Home Data for Enhancing the Living Experience. *Artificial intelligence and smarter living,* Osa/vuosikerta 11, p. 7.

Kane, R. A. & Wilson, K. B., 1993. *Assisted living in the United States: A new paradigm for residential care for frail older persons?.* Washington, DC: American Association of Retired Persons.

Kim, M. J. ym., 2012. A critical review of user studies on healthy Smart Homes. *Indoor and Built Environment.*

Kirkham, T., Armstrong, D., Karim, D. & Jiang, M., 2014. Risk driven Smart Home resource management using cloud services. *Future Generation Computer Systems,* Osa/vuosikerta 38, pp. 13-22.

Lee, C., Nordstedt, D. & Helal, S., 2003. Enabling smart spaces with OSGI. *IEEE Pervasive Computing,* 2(3), p. 89–94.

Lien, C.-H., Bai, Y.-W. & Lin, M.-B., 2007. Remote-controllable power outlet system for home power management. *IEEE Transactions on Consumer Electronics,* 53(4), p. 1634–1641.

Mallett, S., 2004. Understanding home: a critical review of the literature. *The sociological review,* 52(1), p. 62–89.

Michaels, C. F. & Carello, C., 1981. *Direct perception.* NJ: Prentice-Hall Englewood .

Mitchell, J. M. & Kemp, B. J., 2000. Quality of Life in Assisted Living Homes A Multidimensional Analysis. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences,* 55(2), pp. 117-127.

Moore, B., 1984. *Privacy: Studies in social and cultural history.* s.l.:s.n.

Pedrasa, M. A. A., Spooner, T. D. & and MacGill, I. F., 2010. Coordinated scheduling of residential distributed energy resources to optimize smart home energy services. *IEEE Transactions on Smart Grid,* 1(2), p. 134–143.

Peek, S. T. ym., 2014. Factors influencing acceptance of technology for aging in place. *International journal of medical informatics,* 83(4), pp. 235-248.

Portet, F. ym., 2013. Design and evaluation of a smart home voice interface for the elderly: acceptability and objection aspects. *Personal and Ubiquitous Computing,* 17(1), pp. 127--144.

Rashidi, P. & Cook, D., 2009. Keeping the Resident in the Loop: Adapting the Smart Home to the User. *Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions on,* Sept, 39(5), pp. 949-959.

Rialle, V. ym., 2002. . Health" smart" home: information technology for patients at home. *Telemedicine Journal and E-Health,* 8(4), p. 395–409.

Robert, S., Lo, A., Secombe, C. & Wong, Y. K., 2009. Elderly persons' perception and acceptance of using wireless sensor networks to assist healthcare. *International journal of medical informatics,* 78(12), pp. 788-801.

Sadri, F., 2011. Ambient intelligence: A survey. *ACM Computing Surveys (CSUR).*

Santacana, E., Rackliffe, G., Tang, L. & and Feng, X., 2010. Getting smart. *IEEE Power and Energy Magazine,* 8(2), p. 41–48.

Siggelkow, N., 2007. Persuasion with case studies. *Academy of Management Journal ,* 50(1), pp. 20-24.

Snoonian, D., 2003. Smart buildings. *IEEE Spectrum,* 40(8), pp. 18-23.

Somerville, P., 1992. Homelessness and the meaning of home: Rooflessness or rootlessness?. *International Journal of Urban and Regional Research,* 16(4), p. 529–539.

Strong, D. M. ym., 2014. A theory of organization-ehr affordance actualization. *Journal of the Association for Information Systems,* 15(2), p. 53–85.

Suryadevara, N., Mukhopadhyay¸S.C., Wang, R. & Rayudu, R., 2013. Forecasting the behavior of an elderly using wireless sensors data in a smart home. *Engineering Applications of Artificial Intelligence,* 26(10), pp. 2641 - 2652.

Tang, P. & Venables, T., 2000. 'Smart' homes and telecare for independent living.. *Journal of Telemedicine and Telecare,* 6(1), p. :8–14.

United Nations, 2013. *World Population Ageing 2013,* s.l.: Department of Economic and Social Affairs, Population Division ST/ESA/SER.A/348.

Van Hoof, J., Kort, H., Rutten, P. & Duijnstee, M., 2011. Ageing-in-place with the use of ambient intelligence technology: Perspectives of older users. *International journal of medical informatics,* 80(5), pp. 310--331.

Wissner, M., 2011. The smart grid–a saucerful of secrets?. *Applied Energy,* 88(7), p. 2509–2518.

Zamora-Izquierdo, M., Santa, J. & Gomez-Skarmeta, A., 2010. An integral and networked home automation solution for indoor ambient intelligence. *IEEE Pervasive Computing,* 9(4), p. 66–77.

Zimmerman, S., 2001. *Assisted living: Needs, practices, and policies in residential care for the elderly.* s.l.:JHU Press.