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# Preface

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## 1. About this thematic issue

This thematic issue addresses Smart Homes, a phrase that describes domestic living environments fitted with network based sensors, actuators and other appliances which can coordinate their actions to offer new types of holistic system behaviour which are often labelled "smart" or "intelligent" [1]. The term smart homes is frequently synonymise with other phrases such as digital homes, networked homes and intelligent buildings, as all these terms describe systems of interconnected embedded-computers which are capable of local, remote and collective management. Agents, people, or both can orchestrate this holistic networked behaviour [7]. This orchestration of actions across the entire home space reinforces the notion of such a home being smart. Typical applications for smart homes include energy efficient homes, medical or care homes, safe or secure homes or simply enhancing the home's entertainment or communication services [8]. The realisation of smart homes requires the convergence of different disciplines ranging, for example, from computer science, through to sociology [2]. In this issue we have to provide a small snapshot of the current state-of-the art in this area.

## 2. Background

Modern high-tech buildings can be viewed as machines, as they contain numerous interconnected sensors, effectors and computers that collectively control the building's environment. This view was first voiced in the 1920's by Le Corbusier who in his book, "Towards A New Architecture", famously remarked that, "*A house is a machine for living in*" [6]. Le Corbusier's view was of an all-embracing mix of building structures and materials (IT didn't exist then). The arrival of IT extended this view to include service automation; a notable early milestone being the 1975 development of X10 (a power line based home automation technology) by a small Scottish company, PICO (launched to the American DIY market by Radio Shack in 1978 and still in use today!). This was quickly followed by a host of newer building automation and IT standards ranging from dedicated building service protocols such as Lontalk to more generic IT protocols such as IP. However, the arrival of IT bought with it new complexities and challenges; how to configure, program and manage potentially hundreds of embedded-computer systems that may make up a large high-tech building? One answer what the use of techniques borrowed from AI, which is the focus of many of the papers in this issue [5,7]. Such ideas led researchers from robotics to extend Le Corbusier's ideas by likening a building to a robot, coining phrases such as "buildings are robots that people live inside" [3]. These statements are not simply metaphors but are based on a deeper shared problems space which includes the need to deal with sensors that provided noisy, incomplete and sometimes erroneous date, coupled with actuators that are imperfect, environments that can be highly dynamic and complex leading to real-time computational models that were somewhat intractable to construct or maintain. These shared problems led to shared solutions such as the use of computational intelligence techniques, which are evident in this issue. However, smart homes have an essential difference to machines in that they are primarily homes for real people and, as such, places of intense social interaction between people, between embedded-agents and between people and agents. This later dimension has placed an emphasis on HCI and socio technical aspects of smart homes which aim at ensuring that the occupant of a smart home remains in firm control, and is never subservient to the technology [4]. Such goals have been well articulated by smart-home axioms such as; "The User is King/Queen" or "The User Rules" [3]. Science fiction has been quick to pick up on the dangers of not adhering to this design philoso-

phy through Hollywood blockbusters that have featured stories where the "Machine Rules", in such films as "Demon Seed, "The Tower" and Author C Clarke's famous epic 2010. Seven papers are included in this thematic issue that cover an interesting range of topics including techniques for identifying the behaviour of people in a smart homes, processing sensor data to either extract context information or proactively control environments through to managing sensor networks, virtual reality and methodologies for studying people's relationships with smart homes

## 3. The papers

The first paper "*Exploring the responsibilities of single inhabitant Smart Homes with Use Cases*" by Paul Lyons, An Tran Cong, Joe Steinhauer, Stephen Marsland, Jens Dietrich, and Hans Guesgen introduces 'USE cases' as a tool for exploring a single person's relationship with their smart home, with special attention being given to elder-care. The USE cases provide a common language to discover issues and resolve situations. The work is firmly driven by user-concerns and its innovative use of USE cases seems to be a pragmatic and realistic way to address the difficulties posed by occupants who are not able to interact directly with technology. The paper also introduces a useful online web-based repository of USE Cases related to Smart Homes that anyone can use, and to which anyone may contribute.

The second paper "*An intervention mechanism for assistive living in smart homes*" by Shuai Zhang, Sally McClean, Bryan Scotney, Xin Hong, Chris Nugent and Maurice Mulvenna proposes a decision-making framework for smart home environments based on probabilistic models. The approach employs a supervised learning algorithm to learn and predict the behavioural patterns of an inhabitant, with surprisingly accuracy. Modules in the implemented system generate personalized reminders to an inhabitant who may be disoriented or forgetful, etc. The intervention mechanism is especially interesting as it purports to support multi-inhabitant activities.

The third paper "*Activity recognition using temporal evidence theory*" by Susan Mckeever, Juan Ye, Lorcan Coyle, Chris Bleakley and Simon Dobson focuses on the development of an evidential framework which ustilises temporal information for reasoning about home based activities. The ability to identify the behavior of people in a home is at the core of smart home functionality. The authors point out that time is a natural human way to reason about activities and argue that the inclusion of temporal information in activity recognition remains under utilized. They propose a solution based on adapting evidence theory to incorporate time related domain knowledge into the reasoning process and they provide experimental evidence that this approach can offer significant performance improvements for such systems.

The forth paper "*Clustering based fuzzy logic for multimodal sensor networks*: *A preprocessing to decision fusion*" by Rabie Ramadan proposes a set of clustering algorithms for use in multi-feature wireless sensor networks that, differ from existing approaches by taking into account several parameters (e.g. a node's residual energy, similarity of nodes etc.) instead of being based only on the strength of the radio signal. The work provides not only a good solution for wireless sensor networks, but the techniques could have wider applications to other domains.

The fifth paper "*The easy ADL home: A physical-virtual approach to domestic living*" by Dipak Surie, Thomas Pederson and Lars-Erik Janlert presents an interesting perspective on combining physical and virtual realities within an automated home. It uses this perspective to present an architecture together with a related evaluation based on an application for caring for people with mild-dementia (although its not limited to this use). As part of the work the authors present an interesting discussion on the mapping between real and virtual objects that attempts to uniformly address both the physical and virtual aspects of a smart home. The paper includes an evaluation comprising some 20 subjects that provides useful insights to the work.

The sixth paper "*Activity recognition using semi-Markov models on real world smart home datasets*" by Tim van Kasteren, Gwenn Englebienne, and Ben Kröse presents a detailed description of four Markov modeling approaches: hidden Markov models, hidden semi-Markov models, conditional random fields, and semi-Markov conditional random fields that are used to recognize some activities of daily living. The recognition performances of each model using real world data are compared and the main model differences are highlighted. The authors provide a useful evaluation that other smart home researcher should find very useful, such as their findings that hidden semi-Markov models consistently outperform hidden Markov models, and that semi-Markov conditional random fields slightly outperform conditional random fields. A particularly useful aspect is that the datasets used in these experiments are freely avail-

able to the smart-home research community to allow further experimentation.

The seventh and final paper "*Environmental user-preference learning for smart homes: An autonomous approach*" by Luis Ángel San Martín, Víctor M. Peláez, Roberto González, Antonio Campos and Vanesa Lobato describes an architecture that combines a context-management architecture based on an ontology with a machine-learning technique, using the KNN machine learning algorithm, to infer environmental user preferences automatically. The model includes a number of interesting supporting concepts such as filtering tuples based on those affecting the current state, facilitating the independence of hardware devices via a hardware abstraction layer and an interesting discussion on how to handle multi-user issues.

From these 7 papers it is clear that computational intelligence, plays a fundamental role in the functionality of smart-home. Smart-homes are essentially multi-agent environments in which agents are both synthetic (derived from computational intelligence) and natural (real people). Whilst this thematic edition has focused largely on the technology, it is evident that it is also necessary to pay as much attention to the natural agents (people) as we do to the synthetic ones (technology); a successful home is a symbiotic marriage of physical and social science; in other words, the longer term nature of smart home research is intrinsically multidisciplinary.

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