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Towards Sustainable Computing through Ambient Intelligence

J.UCS Special Issue

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Ambient Intelligence (AmI) represents a new generation of user-centred computing environments aiming to find new ways to obtain a better integration of information technology in everyday life devices and activities. On the other hand, Ambient Assisted Living (AAL), is an important application domain of AmI that aims to contribute with ICT research applied to enabling assistive living environments.

AmI environments are integrated by several autonomous computational devices of modern life ranging from consumer electronics to mobile phones. Ideally, people in an AmI and AAL environments will not notice these devices, but they will benefit from the services they provide them. Such devices are aware of the people present in those environments by reacting to their gestures, actions and context. Recently the interest in Ambient Intelligence Environments has grown considerably due to new challenges posed by society, giving place to new interesting associated research disciplines such as Intelligent Transport, Ambient Assisted Living (AAL), e-Health, Internet of Things, Sustainable Computing and Smart Cities among others.

The main focus of this special issue is to explore how Ambient Intelligence can contribute towards Smarter but still more Sustainable Environments (e.g. Smart Cities, Smart Cars, Eco-aware devices and so on). Consequently, a selection of papers addressing key aspects about Sustainability, particularly, but several other key areas and domains within AmI such Smart Environment Configuration, Activity Recognition within Ambient Assisted Living and Ambient Assisted Learning are included. These papers were subjected to additional rounds of anonymous reviews. The revised versions of the selected papers are included in this special issue, covering topics such as the need for minimal use of computation, storage and energy in the Internet of Things powered environments, how mobile devices and public displays may aid in the coordination and orchestration of surrounding smart objects, how ontologies can be used to help further automatizing Smart Environments and to enhance composite activity recognition or how learning can also be enhanced by smarter objects and environments.

Minimal use of computation, energy and storage resources at wireless sensors is paramount to address constrained resources which are commonplace in Smart Environments. The paper "Enabling User Access Control in Energy-constrained Wireless Smart Environments" by Juan Álvaro Muñoz Naranjo et al. introduces a novel access control solution for wireless network services in Internet of Things scenarios. The proposed methods for key distribution and access control rely on extremely fast key derivation functions and, for the same reason, memory usage is reduced since keys are computed on the fly when needed. Their solution achieves privacy, authentication, semantic security, low energy, low computational demand and impacts mitigation of compromised devices on a simple manner. The access control provided is based on user identity and time intervals. These properties are discussed and compared with previous related work, thus providing experimental results that confirm its viability.

Mobile devices are key instruments to facilitate interaction in spaces populated with smart objects. The paper "MECCANO: a Mobile-Enabled Configuration framework to Coordinate and Augment Networks of smart Objects" by Ana Bernardos et al. describes a framework that supports an interaction method for a user to perform physical discovery and versatile configuration of behaviours involving a network of smart objects. Additionally, MECCANO guides the developer to easily integrate new augmented objects in the smart ecosystem. Behaviours are rule-based micro-services composed by a combination of events, conditions and actions that one or more smart objects can trigger, detect or perform. The capabilities provided by a specific object can be merged with those in other objects (including those in the user's mobile device itself) to configure a behaviour involving several objects, adapted to the user's needs. The framework also facilitates sharing micro-services in such a way that users can act as prosumers by generating their self-made behaviours.

Urban spaces are increasingly embedded with various types of public digital displays. Many of these displays can be subject to multi-user interactions and support a broad range of applications. A fundamental implication emerging from the interactive nature of those applications is that users should have access to appropriate selection and control techniques that would allow them to drive the way applications are shown and used in the respective environment. Such techniques should enable each user to reason and express intentions about the system behavior, while also dealing with concurrent requests from multiple users in a way that is fair and clear. The paper "Design Considerations for Application Selection and Control in Multi-user Public Displays" by Constantin Taivan et al. reports several novel techniques for application selection and control in pervasive display environments that can address the above challenges. Drawing inspiration from traditional GUI interaction concepts, they develop and deploy a public display system that supports multiple applications and is able to receive explicit content presentation requests from multiple viewers.

Automatic or semi-automatic configuration of Smart Buildings is still an unresolved challenge that must be addressed to foster a wider deployment of these environments. The paper "Implementation of a Building Automation System based on Semantic Modeling" by Jaime Caffarel et al. presents an Ontology-Based multi-technology platform designed to allow the integration of several building automation protocols, to ease the development and implementation of different kinds of services

and to allow sharing information related to the infrastructure and facilities within a building. The system has been implemented and tested in a real Energy Efficiency Research Facility.

The lack of a standard format to store data generated within the smart environments research domain is limiting the opportunity for researchers to share and reuse datasets. The opportunity to exchange datasets is further hampered due to the lack of an online resource to facilitate this. The paper "Assessing the Impact of the homeML Format and the homeML Suite within the Research Community" by Heather McDonald et al. aims to resolve these issues through the development of homeML, a proposed format to support the storage and exchange of data generated within a smart environment and the homeML suite, an online tool to support data exchange and reuse. A usability and functionality study performed concludes that the homeML format could address the need for a standard format within this domain and that it would be a useful tool to be available to researchers as they perform experiments in the area of smart environments.

Activity recognition enables ambient assisted living applications to provide activity-aware services to users in smart homes. Despite significant progress being made in activity recognition research, the focus has been on simple activity recognition leaving composite activity recognition an open problem. For instance, knowledge-driven activity recognition has recently attracted increasing attention but mainly focused on simple activities. The paper "An Agent-mediated Ontology-based Approach for Composite Activity Recognition in Smart Homes" by George Okeyo et al. extends previous work by introducing a knowledge-driven approach to recognition of composite activities such as interleaved and concurrent activities. The approach combines the recognition of single and composite activities into a unified framework. To support composite activity modelling, it combines ontological and temporal knowledge modelling formalisms. In addition, it exploits ontological reasoning for simple activity recognition and qualitative temporal inference to support composite activity recognition. The approach is organized as a multi-agent system to enable multiple activities to be simultaneously monitored and tracked.

"Human-Centric Interfaces for Ambient Intelligence" and "Collaborative Smart Objects" technologies are two interesting AmI research areas with ample possibilities in the learning domain. The paper "CUBICA: An Example of Mixed Reality" by Juan Mateu et al. presents their efforts in developing these technologies for "Mixed Reality", a paradigm where Virtual Reality and Ambient Intelligence meet. CUBICA is a mixed reality educational application that integrates virtual worlds with tangible interfaces. The application is focused on teaching computer science, in particular "sorting algorithms". The tangible interface is used to simplify the abstract concept of array, while the virtual world is used for delivering explanations. This educational application has been tested with students at different educational levels in secondary education, having obtained promising results in terms of increased motivation for learning and better understanding of abstract concepts.

Creating challenging learning conditions through play and entertainment thanks is also possible through AmI. The paper "A Multimodal Ambient Intelligence Environment for Playful Learning" by Haris Papagiannakis et al. reports the design, development and evaluation of a technological framework for learning applications,

named AmI Playfield. This work defines an educative Ambient Intelligent (AmI) environment which emphasizes the use of kinesthetic and collaborative technology in a natural playful learning context and embodies performance measurement techniques. In order to test and assess AmI Playfield, the "Apple Hunt" application is developed, which engages (young) learners in arithmetic thinking through kinesthetic and collaborative play, observed by unobtrusive AmI technology behind the scene.

The proceedings of the 6th International Symposium on Ubiquitous Computing and Ambient Intelligence (UCAmI 2012) & 4th International Workshop on Ambient Assisted Living (IWAAL 2012), where the original non-extended versions of these papers appear, were published as books entitled "Ubiquitous Computing and Ambient Intelligence" with ISBN 978-3-642-35377-2 and "Ambient Assisted Living and Home Care" with ISBN 978-3-642-35395-6, at Springer's Lecture Notes in Computer Science series. We gratefully acknowledge the anonymous reviewers as well as the program committee members of UCAmI 2012 & IWAAL 2012 for their help in selecting the papers for this special issue. Finally we would like to thank the referees of this special issue for the high quality of their reviews.

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