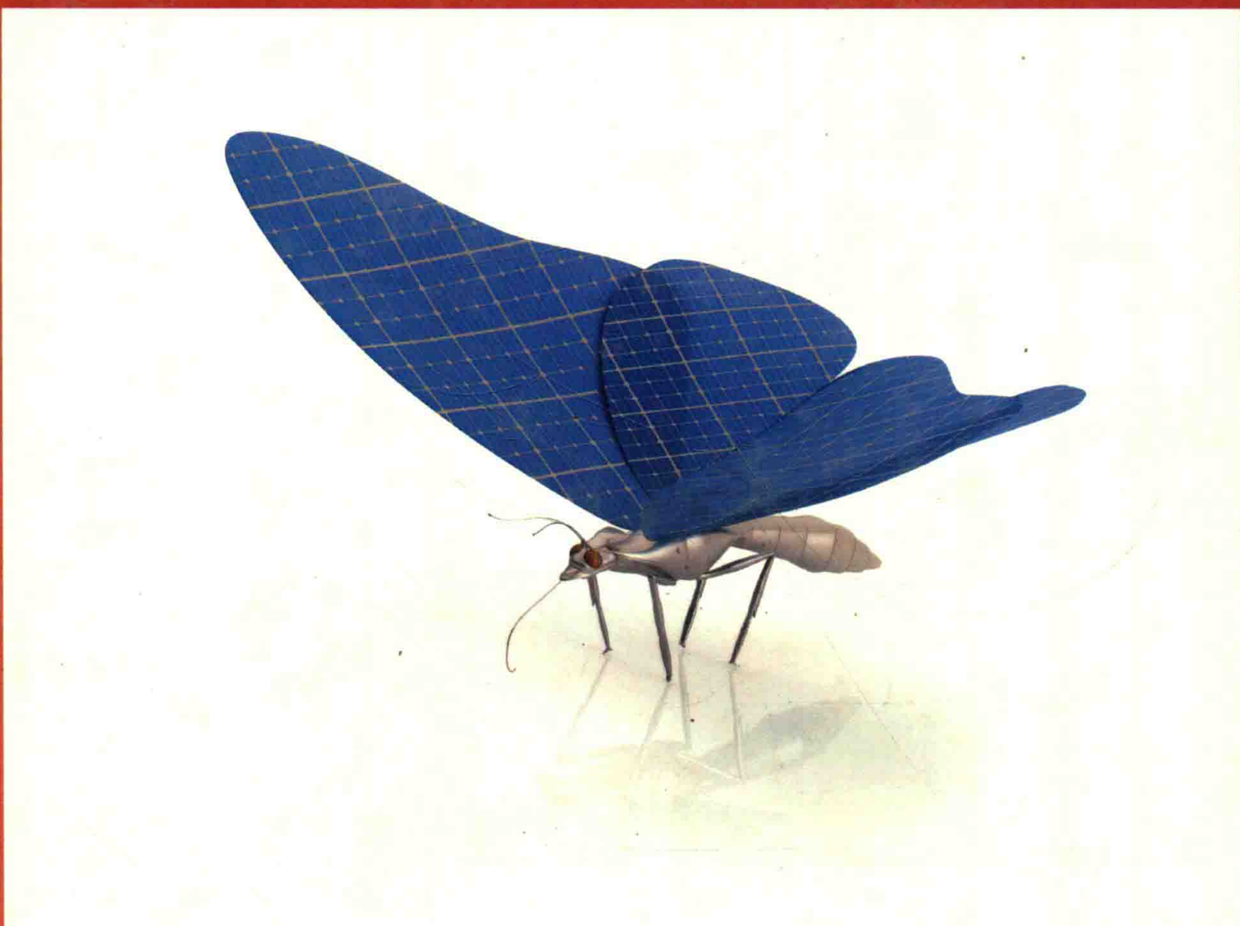
HANDBOOK OF RESEARCH ON

Ambient Intelligence and Smart Environments

Trends and Perspectives



Nak-Young Chong & Fulvio Mastrogiovanni

Handbook of Research on Ambient Intelligence and Smart Environments:

Trends and Perspective

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In memory of Giuseppe Mastrogiovanni.

— F. M.

To my family - Dohee, Woohyon, and Woojin

— N. Y. C.

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Ambient Intelligence as Cognitive Niche Enrichment: Foundational Issues 1
Lorenzo Magnani, University of Pavia, Italy
Emanuele Bardone, University of Pavia, Italy

We will introduce some cognitive and epistemological foundational aspects related to Ambient Intelligence (AmI). We will show how three concepts which derive from the tradition of cognitive science may be of help in deepening some of the main theoretical aspects concerning Ambient Intelligence: the notion of distributed cognition, the concept of cognitive niche, and the concept of affordance. We contend that this theoretical perspective will shed new light on some of the most promising and interesting developments recently brought about by Ambient Intelligence.

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Christine Leignel, Université Libre de Bruxelles, Belgium
Jean-Michel Jolion, Université de Lyon, France

This chapter presents a survey of methods used for tracking in video sequence. We mainly focus this survey on tracking persons. We introduce three main approaches. First, we present the graph based tracking approach where the sequence of tracked objects are embodied in a graph structure. Then we introduce the features (extracted from the images) based tracking and matching with a model. We survey the main primitives and emphasize the approaches based on 2D and 3D body model. We present the particular case of tracking in a network of cameras with the particle filtering method. Finally, As a generalization, we focus on the single vs. stereo approaches.

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Axel Steinhage, Future-Shape GmbH, Germany
Christl Lauterbach, Future-Shape GmbH, Germany

The following chapter describes two systems, both are perfect examples for ambient intelligence. The first system is, sensor electronics, which is invisibly integrated into the floor. This system is able to detect people walking across the floor and can be used to recognize peoples' location and movement behavior. The main application domains are Ambient Assisted Living (AAL), health care, security systems and home automation. The second system serves for localizing moving objects such as robots, wheelchairs or hospital beds by means of RFID tags in the floor. In the following, we describe the technical details of the two systems and possible applications.

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Embedding Context-Awareness into a Daily Object for Improved Information Awareness:
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Kaori Fujinami, Tokyo University of Agriculture and Technology, Japan
Fahim Kawsar, Lancaster University, UK

In this chapter, a case study on augmenting a daily object, mirror, for a contextual ambient display is presented. The mirror presents information relevant to a person who is standing and utilizing unshareable objects, e.g. a toothbrush, in front of it on the periphery of his/her field of vision. We investigated methods of interaction with the mirror by analyzing user preferences against contrastive functionalities. Experiments were conducted by a Wizard-of-Oz method and an in-situ experiment. The results showed that a short absence of the mirror function was not a big issue for the majority of participants once they were interested in presented information. The analysis also allowed us to specify requirements and further research questions in order to make an augmented mirror acceptable.

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Yang Cai, Carnegie Mellon University, USA
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No Ambient Intelligence can survive without human-computer interactions. Over ninety percent of information in our communication is verbal and visual. The mapping between one-dimensional words and two-dimensional images is a challenge for visual information classification and reconstruction. In this Chapter, we present a model for the image-word two-way mapping process. The model applies specifically to facial identification and facial reconstruction. It accommodates through semantic differential descriptions, analogical and graph-based visual abstraction that allows humans and computers to categorize objects and to provide verbal annotations to the shapes that comprise faces. An image-word mapping interface is designed for efficient facial recognition in massive visual datasets. We demonstrate how a two-way mapping of words and facial shapes is feasible in facial information retrieval and reconstruction.

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Ricardo Santos, Polytechnic Institute of Porto, Portugal

This Chapter is a survey dealing with the use of emotions and mood to characterize an Ambient Intelligence system. In particular, a key aspect of the described research is the assumption that each level of an Ambient Intelligence infrastructure (e.g., sensing, reasoning, action) can benefit from the introduction of emotion and mood modelling. The Chapter surveys well-known models (e.g., OCC, Big Five – Five Factor Model, PAD, just to name a few) discussing for each one Pros and Cons. Next, architectures for emotional agents are discussed, e.g., Cathexis (assuming the somatic marker hypothesis proposed by Damasio), Flame, Tabasco and many others. Finally, specific implementation examples of emotional agents in Ambient Intelligence scenarios are described.

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Ambient Intelligence (AmI) is the art of designing intelligent and user-focused environments. It is thus of great importance to take human factors into account. In this chapter we especially focus on emotions, that have been proved to be essential in human reasoning and interaction. To this end, we assume that we can take advantage of the results obtained in Artificial Intelligence about the formal modeling of emotions. This chapter specifically aims at showing the interest of logic as a tool to design agents endowed with emotional abilities useful for Ambient Intelligence applications. In particular, we show that modal logics allow the representation of the mental attitudes involved in emotions such as beliefs, goals or ideals. Moreover, we illustrate how modal logics can be used to represent complex emotions (also called self-conscious emotions) involving elaborated forms of reasoning, such as self-attribution of responsibility and counterfactual reasoning. Examples of complex emotions are regret and guilt. We illustrate our logical approach by formalizing some case studies concerning an intelligent house taking care of its inhabitants.

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In this chapter, we propose to outline the scientific area that addresses Ambient Intelligence applications in which not only sensor data, but also knowledge from the human-directed sciences such as biomedical science, neuroscience, and psychological and social sciences is incorporated. This knowledge enables the environment to perform more in-depth, human-like analyses of the functioning of the observed humans, and to come up with better informed actions. A structured approach to embed human knowledge in Ambient Intelligence applications is presented an illustrated using two examples, one on automated visual attention manipulation, and another on the assessment of the behaviour of a car driver.

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Tatsuya Yamazaki, National Institute of Information and Communications Technology, Japan

This book chapter provides a review of the assistive technologies deployed in smart spaces with a variety of smart home or house examples. In the first place, home networking technologies and sensing technologies are surveyed as fundamental technologies to support smart environment. After reviewing representative smart home projects from across the world, concrete assistive services related with the fundamental technologies in smart environment are deployed not only for the elderly and handicapped but for people in ordinary families as well. Adaptability is one of the key essences in the assistive technologies in smart environment and, for this purpose, human-ware studies including man-machine interfaces, ergonomics and gerontology are needed to be linked with the hardware specific fundamental technologies.

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Francisco J. Ballestero, Universidad Rey Juan Carlos, Spain
Enrique Soriano, Universidad Rey Juan Carlos, Spain
Gorka Guardiola, Universidad Rey Juan Carlos, Spain

There are some important requirements to build effective smart spaces, like human aspects, sensing, activity recognition, context awareness, etc. However, all of them require adequate system support to build systems that work in practice. In this chapter, we discuss system level support services that are necessary to build working smart spaces. We also include a full discussion of system abstractions for pervasive computing taking in account naming, protection, modularity, communication, and programmability issues.

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Oleg Davidyuk, ARLES Research Team, INRIA, France and University of Oulu, Finland,
Nikolaos Georgantas, ARLES Research Team, INRIA, France
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Activity-oriented computing (AOC) is a paradigm promoting the run-time realization of applications by composing ubiquitous services in the user's surroundings according to abstract specifications of user activities. The paradigm is particularly well-suited for enacting ubiquitous applications. However, there is still a need for end-users to create and control the ubiquitous applications because they are better aware of their own needs and activities than any existing context-aware system could ever be. In this chapter, we give an overview of state of the art ubiquitous application composition, present the architecture of the MEDUSA middleware and demonstrate its realization, which is based on existing open-source solutions. On the basis of our discussion on state of the art ubiquitous application composition, we argue that current implementations of the AOC paradigm are lacking in end-user support. Our solution, the MEDUSA middleware, allows end-users to explicitly compose applications from networked services, while building on an activity-oriented computing infrastructure to dynamically realize the composition.

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Jochen Meis, Fraunhofer Institute for Software and System Engineering, Germany
Manfred Wojciechowski, Fraunhofer Institute for Software and System Engineering, Germany

This Chapter deals with the important process related to smart environments engineering, with a specific emphasis on the software infrastructure. In particular, the Chapter focuses on the whole process, from the initial definition of functional requirements to the identification of possible implementation strategies. On the basis of this analysis, a context model as well as the possible choice of relevant sensor types is carried out.

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Baoying Wang, Waynesburg University, USA
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Ambient Intelligence is the concept that technology will become a part of everyday living and assist users in multiple tasks. It is a combination and further development of ubiquitous computation, pervasive computation, and multimedia.The technology is sensitive to the actions of humans and it can interact with the human or adjust the surroundings to suit the needs of the users dynamically. All of this is made possible by embedding sensors and computing components inconspicuously into human surroundings. This paper discusses the middleware needed for dynamic ambient intelligence networks and the ambient intelligence network architecture. The bottom-up middleware approach for ambient intelligence is important so the lower layers of all ambient intelligence networks are interchangeable and compatible with other ambient intelligence components. This approach also allows components to be programmed to be compatible with multiple ambient intelligence networks. The network architecture discussed in this paper allows for dynamic networking capabilities for minimal interruptions with changes in computer components.

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Weishan Zhang, China University of Petroleum, P.R. China
Klaus Marius Hansen, University of Copenhagen, Denmark

Abstract Context-awareness is an important feature in Ambient Intelligence environments including in pervasive middleware. In addition, there is a growing trend and demand on self-management capabilities for a pervasive middleware in order to provide high-level dependability for services. In this chapter, we propose to make use of context-awareness features to facilitate self-management. To achieve self-management, dynamic contexts for example device and service statuses, are critical to take self-management actions. Therefore, we consider dynamic contexts in context modeling, specifically as a set of OWL/SWRL ontologies, called the Self-Management for Pervasive Services (SeMaPS) ontologies. Self-management rules can be developed based on the SeMaPS ontologies to achieve self-management goals. Our approach is demonstrated within the Hydra pervasive middleware. Finally, our experiments with performance, extensibility, and scalability in the context of Hydra show that the SeMaPS-based self-management approach is effective.

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A general infrastructure that can facilitate the development of context-aware applications in smart homes is proposed. Unlike previous systems, our system builds on semantic web technologies, and it particularly concerns the contexts from human-artifact interaction. A multi-levels' design of our ontology (called SS-ONT) makes it possible to realize context sharing and end-user-oriented customization. Using this infrastructure as a basis, we address some of the principles involved in performing context querying and context reasoning. The performance of our system is evaluated through a series of experiments.

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The work is motivated by the expanding demand and limited supply of long-term personal care for People with Dementia (PwD), and assistive technology as an alternative. Telecare allows PwD to live in the comfort of their homes for a longer time. It is challenging to have remote care in smart homes with ambient intelligence, using devices, networks, and activity and plan recognition. Our scope is limited to mostly related work on existing execution environments in smart homes, and activity and plan recognition algorithms which can be applied to PwD living in smart homes. PwD and caregiver needs are addressed in a more holistic healthcare approach, domain challenges include doctor validation and erroneous behaviour, and technical challenges include high maintenance and low accuracy. State-of-the-art devices, networks, activity and plan recognition for physical health are presented; ideas for developing mental training for mental health and social networking for social health are explored. There are two implications of this work: more needs to be done for assistive technology to improve PwD's mental and social health, and assistive software is not highly accurate and persuasive yet. Our work applies not only to PwD, but also the elderly without dementia and people with intellectual disabilities.

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Patrice C. Roy, Université de Sherbrooke, Canada
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In order to provide adequate assistance to cognitively impaired people when they carry out their activities of daily living (ADLs) at home, new technologies based on the emerging concept of Ambient Intelligence (AmI) must be developed. The main application of the AmI concept is the development of Smart Homes, which can provide advanced assistance services to its occupant when he performs his ADLs. The main difficulty inherent to this kind of assistance services is to be able to identify the ongoing inhabitant ADL from the observed basic actions and from the sensors events produced by these actions. This chapter will investigate in details the challenging issues that emerge from activity recognition in order to provide cognitive assistance in Smart Homes, by identifying gaps in the capabilities of current approaches. This will allow to raise numerous research issues and challenges that need to be addressed for understanding this research field and enabling ambient recognition systems for cognitive assistance to operate effectively.

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Fariba Sadri, Imperial College London, UK

In this chapter we discuss intention recognition in general, and the use of logic-based formalisms, and deduction and abduction in particular. We consider the relationship between causal theories used for planning and the knowledge representation and reasoning used for intention recognition. We look at the challenges and the issues, and we explore eight case studies.

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Katsunori Oyama, Iowa State University, USA
Carl K. Chang, Iowa State University, USA
Simanta Mitra, Iowa State University, USA

Most of context models have limited capability in involving human intention for system evolvability and self-adaptability. Human intention in context aware systems can evolve at any time, however, context aware systems based on these context models can provide only standard services that are often insufficient for specific user needs. Consequently, evolving human intentions result in changes in system requirements. Moreover, an intention must be analyzed from tangled relations with different types of contexts. In the past, this complexity has prevented researchers from using computational methods for analyzing or specifying human intention in context aware system design. The authors investigated the possibility for inferring human intentions from contexts and situations, and deploying appropriate services that users require during system run-time. This chapter first focus on describing an inference ontology to represent stepwise inference tasks to detect an intention change and then discuss how context aware systems can accommodate requirements for the intention change.

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Victor Siang-Fook Foo, Institute for Infocomm Research, Singapore
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This chapter provides examples of sensor data acquisition, processing and activity recognition systems that are necessary for ambient intelligence specifically applied to home care for the elderly. We envision a future where software and algorithms will be tailored and personalized towards the recognition and assistance of Activities of Daily Living (ADLs) of the elderly. In order to meet the needs of the elderly living alone, researchers all around the world are looking to the field of Ambient Intelligence or AmI (see http://www.ambientintelligence.org).

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Björn Gottfried, University of Bremen, Germany

This Chapter provides an introduction to the emerging field of Behaviour Monitoring and Interpretation (BMI in short). The study of behaviour encompasses both social and engineering implications: on one hand the scientific goal is to design and represent believable models of human behaviours in different contexts; on the other hand, the engineering goal is to acquire relevant sensory information in real-time, as well as to process all the relevant data. The Chapter provides a number of examples of BMI systems, as well as discussions about possible implications in Smart Environments and Ambient Intelligence in a broad sense.

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Hans W. Guesgen, Massey University, New Zealand
Stephen Marsland, Massey University, New Zealand

Identifying human behaviours in smart homes from sensor observations is an important research problem. The addition of contextual information about environmental circumstances and prior activities, as well as spatial and temporal data, can assist in both recognising particular behaviours and detecting abnormalities in these behaviours. In this chapter, we describe a novel method of representing this data and discuss a wide variety of possible implementation strategies.

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Claus Moebus, University of Oldenburg, Germany
Mark Eilers, University of Oldenburg, Germany

The Human or Cognitive Centered Design (HCD) of intelligent transport systems requires digital Models of Human Behavior and Cognition (MHBC) enabling Ambient Intelligence e.g. in a smart car. Currently MBHC are developed and used as driver models in traffic scenario simulations, in proving safety assertions and in supporting risk-based design. Furthermore, it is tempting to prototype assistance systems (AS) on the basis of a human driver model cloning an expert driver. To that end we propose the Bayesian estimation of MHBCs from human behavior traces generated in new kind of learning experiments: Bayesian model learning under driver control. The models learnt are called Bayesian Autonomous Driver (BAD) models. For the purpose of smart assistance in simulated or real world scenarios the obtained BAD models can be used as Bayesian Assistance Systems (BAS). The critical question is, whether the driving competence of the BAD model is the same as the driving competence of the human driver when generating the training data for the BAD model. We believe that our approach is superior to the proposal to model the strategic and tactical skills of an AS with a Markov Decision Process (MDP). The usage of the BAD model or BAS as a prototype for a smart Partial Autonomous Driving Assistant System (PADAS) is demonstrated within a racing game simulation.

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Bernd Krieg-Brückner, Universität Bremen, Germany
Hui Shi, Universität Bremen, Germany
Bernd Gersdorf, Universität Bremen, Germany
Mathias Döhle, Universität Bremen, Germany
Thomas Röfer, Universität Bremen, Germany

In this chapter, we first briefly introduce the setting: mobility assistants (the wheelchair Rolland and iWalker) and smart environment control in the Bremen Ambient Assisted Living Lab. In several example scenarios, we then outline our contributions to the state of the art, focussing on spatial knowledge representation, reasoning and spatial interaction (multi-modal, but with special emphasis on natural language dialogue) between three partners: the user, a mobility assistant, and the smart environment.

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Marcello Cirillo, Örebro University, Sweden
Federico Pecora, Örebro University, Sweden
Alessandro Saffiotti, Örebro University, Sweden

The main goal of this Chapter is to introduce SAM, an integrated architecture for concurrent activity recognition, planning and execution. SAM provides a general framework to define how an intelligent environment can assess contextual information from sensory data. The architecture builds upon a temporal reasoning framework operating in closed-loop between physical sensing and actuation components in a smart environments. The capabilities of the system as well as possible examples of its use are discussed in the context of the PEIS-Home, a smart environment integrated with robotic components.