Spatial Modeling Factors in Sensor-Based Ambient Assisted Living Technologies Designed for Ageing Populations

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Abstract. In this paper, we synthesize research on the different emerging Ambient Assisted Living (AAL) sensor-based technologies and examine the spatial parameters that are used in these systems. Different lenses in examining the AAL literature are considered, such as the chronological development in sensor-based AAL and the human factors in the design of sensor-based AAL in various contexts. Relevant metrics and standards in AAL design are highlighted. A comparative prospective of these metrics and how they are applied in recent studies and systems are also discussed. The paper presents a categorization of those technologies based on their selection of the spatial information to obtain a clearer understanding of the relationship between spatial modeling and the accuracy of these technologies. Implications for the design of AAL and situated interaction in AAL contexts are discussed.

Keywords: AAL sensors · AAL human factors · Spatial metrics

1 Introduction

Technologies in every aspect of daily living have been evolving to adapt to smarter environments [1]. One of the main goals of smart environments is to provide adequate support and improve the abilities of its occupants and give the users the ability to live an independent life. Ageing involves progressive decline of cognitive, sensory and physical abilities. This consequently has led to a proliferation of Ambient Assisted Living (AAL) research as it became more viable and important for a growing population. Recent studies have shown the impact of AAL technologies on the quality of life for people with visual impairments [2], and with mobility impairments [3]. According to the aging statistics that are provided by the Administration for Community Living (ACL) in the US [4], the older population (persons 65 years or older) represented 12.9 % of the U.S. population; i.e. around 40 million. However, the ACL is expecting that in 2030, there will be about 72.1 million older persons, more than twice their number in 2000. An increase in aging rates is also accompanied by an increase of dependency levels and of life expectancy levels that increase complexity of ageing issues [3].

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AAL technologies have the potential to provide ageing populations with autonomy, mobility, and independence and consequently improve their quality of life. Smart environments could be the most useful solutions for elderly people who need assistance in their Activities of Daily Living (ADL) by alleviating the caregivers from the burden of some responsibilities and simplifying the tasks executed by the elderly [5]. In this context, evidence suggests potential contribution via technology solutions and the need to develop cost-effective solutions for improving care for the elderly in a non-intrusive way, which can, in turn, improve their independent living in their own environments at home [3].

Ambient Assisted Living (AAL) is a term that includes concepts, products, and services, which improve the interaction between technical and social systems to increase quality of life in all areas. AAL solutions mainly aim at supporting people with special needs through technology. AAL technology intends to accomplish that via intelligent interaction with surrounding environments mediated by devices [3]. These systems are important for physically impaired and elderly people to maintain an independent living in their own homes. They help in improving their living in several domains: sensing, reasoning, acting, communication, and interaction. Therefore, AAL is an important application of the emerging Smart Homes field. Information and Communication Technology (ICT) provides several solutions for improving daily life and health condition [6]. Some of these solutions are technologies that monitor the elderly and aim to enhance their sight and hearing senses [7], reduce the risk of falls and detect falls while navigating [8, 9], provide a social network platform for the elderly [10], assist in sleeping [11, 12], and track their daily routine [13].

In the context of AAL for the elderly, this paper examines the different emerging AAL sensor-based technologies studies and proposed systems, concentrating on the selection of spatial parameters that are used in those studies. A synthesis of human factors in the design of sensor-based AAL in previous work is also reported. Relevant metrics and standards to this field are presented; for example, the sensor type, patient dependence level, sensor detection range, and number of sensors. A comparative prospective of these metrics and how they are being followed in recent studies and systems are also discussed [14]. Further, the paper presents a categorization of those technologies based on their selection of the spatial information to get a clearer understanding on the importance of carefully deciding spatial information and their impact on the accuracy of the study's results [15, 16]. Implications for the design of AAL and situated interaction in AAL contexts are discussed.

2 Sensor-Based AAL Technologies

In recent years, varied approaches have been reported for categorizing sensor-based technologies designed for the elderly. The authors in [17] summarized the state-of-the-art AAL technologies, techniques, and tools. In their paper, they categorized the main AAL technologies into: ambient sensors used in smart environments, assistive smart home projects, mobile and wearable sensors and assistive robotics. They organized nine ambient sensors in a table based on measurement (e.g. motion, identification, and pressure) while taking data format (e.g. numeric, image, and sound) into account, whereas assistive smart home projects were arranged according to the educational institution where they were first employed; for instance, CASAS project at Washington State University, DOMUS project at the University de Sherbrooke, and House_n project at the MIT. Wearable and mobile sensors that are equipped in AAL technologies were categorized in the paper according to the measured properties. The required data rate used to detect activities is also shown in the wearable and mobile sensors categorization tables. For example, accelerometer and gyroscope capture acceleration and orientation; therefore, a high sampling rate is needed to detect activities such as running while other physiological measurements such as body temperature will not change abruptly so occasional data sampling will suffice. In addition, assistive robots were categorized into three categories in the paper; robots assisting with ADL activities, robots assisting with instrumental activities of daily living (IADL), and robots assisting with enhanced activities of daily living (EADL). The authors also reviewed the different computational techniques that support AAL tools such as the activity recognition and context modelling techniques.

Innovative AAL designs included monitoring sensors and spatial wireless monitoring solutions. Most of the wireless sensors operate using communication standards such as WiFi, Bluetooth, and ZigBee. In addition, there are a few proprietary solutions that were spatially adopted for biomedical monitoring applications (e.g. [18]). Information and communication technologies (ICT) are being developed continuously to meet the challenges that emerge in medical, healthcare or social contexts. The authors in [19] described the methodological considerations for wireless sensor networks (WSNs) in AAL environments by detailing the following sections: specification of open distributed systems, specification of requirements, and development and evaluation process. The authors also concluded that applying distributed and open paradigm to a distributed biomedical sensor network paradigm will result in improving the power autonomy without affecting the system operations. Research has shown that AAL systems can provide some independence and autonomy for individuals with impairments to make their lives much easier. Different approaches could be adopted to develop AAL systems that involve the use of multi-sensor data fusion techniques. Other research projects (e.g. [20]) were examined ambient sensors solutions that are used in AAL environments by considering spatial-temporal aspects. In [20], the authors discussed the challenges of estimating the accuracy of user's position in environment. They provided a novel approach to solve this issue using an advanced system. This paper focused on RESIMA system, which assists people with sensory disability and those who suffer from visual impairment in indoor environment in particular. RESIMA system, which is an intelligent assisted system based on several sensors those were used to monitor user's status and position. In addition, this system exploited technologies and tools such as Wireless Sensor Network, user-environment interaction (UEI), user-environment contextualization (UEC), decision support system (DSS), and graphical user interface (GUI). They were adopted in order to establish RESIMA system. They aim to manage the interaction of user by sending notification to the user about obstacles or services existed, along with high spatial resolution.

In examining recent additions to the extant knowledge base in AAL sensor technologies, we first considered categorizing the AAL technologies according to the services provided by each technology. Two questions guided the enquiry: 'What are the main issues reported in the literature with regards to AAL sensor technologies in general and to the elderly in specific?' and 'What insights have emerged in AAL sensor technologies for the elderly?'

A number of services emerged as distinct categories in this domain (listed in Table 1):

- Cognitive reinforcement services that enhance the cognitive functions of the user.
- Patient-specific home care services include social reinforcement services, services capable to detect abnormalities, and services capable of monitoring several disease risk factors.
- General home care services include medication reminder services, information services, notification systems for emergency response and intrusion, as well as alarm services in cases of abnormal health conditions

Table 1. Categorization of AAL sensor-based services

Project/System	Services/Application Domains			Reference
	Cognitive Reinforcement	Patient-Specific Home Care	General Home Care	
HERA	✓	✓	✓	Spanoudakis [21]
AALISABETH		✓		Culmone [22]
Fall Preventive iTV Solution		✓		Aal [8]
UMBS		✓		Walsh [11]
eWatch		✓		Maurer [23]
EMERGE		✓	✓	Stelios [24]
GERHOME		✓		Zouba [25]
Autominder	✓		✓	Pollack [26]
Maya MedMinder	✓			Alzheimer's Association [27]
Distributed Vision-Based Analysis System		✓		Aghajan [9]
RGB-D Camera			✓	Jungong [1]
Smart House		✓		Barger [28]
SOPRANO			✓	Klein [29]
Health Informatics System		✓	✓	Suryadevara [16]

One lens in examining the literature is to look at the chronological developments in the field over the past two decades. In this field, it is interesting to note that AAL research has appeared in journals and conferences related to other fields as sub-research topics in consumer electronics [1, 28], mechatronics [22], medicine and biology [11] [21], artificial intelligence [26, 29], multimedia [24], pervasive computing [9], and sensor technologies [16, 18, 23]. Other AAL research for the elderly was included in conferences related to technologies assisting people with special needs such as the International Conference on Computers Helping People with Special Needs. AAL research matured as a standalone discipline and started appearing in conferences and journals in 1994. The first conference that was conducted to explore the use of computing and information technologies to help persons with disabilities and older adults was the ASSET'94, the International ACM/SIGCAPH Conference on Assistive Technologies and it was in 1994. Around a decade later in 2003, other conferences were started such as the AAATE 2003 by the Association for the Advancement of Assistive Technology in Europe. Another conference is the International Conference on Ubiquitous Computing and Ambient Intelligence UCAml, which was first launched in 2005 in Spain. Also, the first Smart Objects and Ambient Intelligence conference was held in 2005, and it explored AAL tools and techniques for augmenting environments with smart, networked, interacting objects [30]. The PErvasive Technologies Related to Assistive Environments (PETRA) conference focuses on computational and engineering approaches to improve the quality of life by providing solutions for the in-home care of the elderly as well as for the care of people with Alzheimer's, Parkinson's and other disabilities or traumas. PETRA was first conducted in 2008. Further, the first volume of the Journal of Ambient Intelligence and Smart Environments was published in January 2009. The journal covers broad areas such as sensors, human cantered interfaces, and societal applications within the field of smart environments and ambient intelligence. Recently, several research groups have been established to tackle AAL issues such as Ambient Intelligence Group CITEC in Bielefeld University [31], AMBIT research group in Artesis University College of Antwerp [32], AmIVital [33], iAMEA International Ambient Media Association [34], and NTT [35].

Of particular interest to the AAL community for the elderly are new insights related to human factors and ergonomics. Early AAL technologies for the elderly focused on providing cognitive, physical, and assistive home services to the elderly. Many of the early-developed technologies overlooked the human factors and issues involved. For example, lack of privacy and security of the elderly or their caretakers, usability of these technologies, user-friendliness, personalization and obtrusiveness were among the issues that emerged from using the AAL technologies. The sensitivity of these technologies and responsiveness needed have called for further research into the field to resolve the issues. A development in maturity of awareness within different stakeholder groups and a development of interest in research in the AAL sensor-based technologies field can be observed. Finally, for the professionals interested in issues of spatial modelling factors, limited effort has been reported. The review of existing literature about AAL sensor-based technologies revealed that spatial modelling factors are still vastly unexplored. The following section examines these factors in more depth.

3 Relevant Metrics and Standards in AAL

The research is designed to propose a categorization of the AAL sensor-based technologies based on their spatial information to obtain a clearer understanding on the importance of considering spatial information in AAL design, and their impact on the accuracy on the systems. The research is exploratory in nature. The following process is followed: first, the collection of archived papers to collate the spatial design considerations in AAL. A synthesis of human factors in the design of sensor-based AAL in previous work is reported and the implications for the design of AAL and situated interaction in AAL contexts elaborates described.

When deciding to localize AAL system, we should consider some metrics addressing accuracy, efficiency, and result optimization. In this section, we discuss the metrics observed from the surveyed research papers and the properties related to each metric (summarized in Table 2). The distance is a one of the metrics that must be taken into consideration. The distance value varies based on the purpose of designing the AAL system. For example, an AAL system that allows the elderly to avoid collisions requires different distance measurements than a system designed for localization sensors nodes aim. In this matter, there have been experiments reported in [20] which were conducted to test the system performance in collision avoidance and to test the services exploitation. The authors observed that successful result of collision avoidance is proportional to the distance between the user's position and obstacles. They concluded that in this case the optimized result is 86 % in 0.75 m. On the other hand, they noted that the successful result of services exploitation is optimized for a specific distances between the service and user's position. These specific values are appropriate to the user and service positions that assure that the positioning is within an appropriate range. The overall result of both tests illuminated that the reliable UEI functionality when the value of compatible distance between user's position and obstacle/service is (~ 1 m) and the optimized resolution of the localization system is (~ 4 cm). In addition, the authors considered other metrics to conduct their experiment such as the distance between two nodes, area size, height of nodes, and the number of nodes used based upon the area size.

With regards to the distance between a user and a node, research has shown that the accuracy of distance between the user and nodes could have an influence on the system accuracy for estimating the user's position [36]. The sensor's range and coverage ability are important factors to be considered when setting the sensors' position [36]. This also affects the number of sensors placed in a specific area. The range of coverage for sensors is also an important factor in design. Sometimes, the radio frequency wave cannot pass through barriers so designers/architects increase the number of sensors in that area [36, 37].

The distance, area size, and height metrics play a role that is emphasized in AAL research papers. The authors in [24] specified the exact position measurements for the sensors in order to evaluate the suggested localization platform for ambient assisted living in an indoor environment, this platform was part of the EMERGE system. There were four Ubisense sensors (Ubisensors) positioned on the ceiling of ordinary office with an area dimension of 6.5 m × 13.45 m × 2.70 m. The coordinates for the first, second, third, fourth sensor were (5.25 m × 0.70 m × 2.75 m), (5.24 m × 12.53 m × 2.52 m), (0.55 m × 11.86 m × 2.52 m), and (5.25 m × 0.70 m × 2.54 m) consecutively with battery powered tags (Ubitag) attached at a height of 1 m. Thus, in this paper the authors considered the area size and high metrics.

Table 2. Metrics of sensor-based Ambient Assisted Living technologies

Metric	Purpose	Properties	Optimized value
Distance	Collisions avoidance/Services exploitation	- Distance between user's position and obstacle/service	~1 m
		- UEI algorithm	
	Distribution of sensor nodes	Distance between two nodes	~4 m
	Accuracy of localizing user position	Distance between the user and node	
	Data transition (Inter-ban)	- Distance between sensors located on user's body and the device	> = 10 m
		- Inter-Ban communication using Bluetooth or WiMedia protocol	
		- Distance between sensors located on user's body and the device	> = 20 m
		- Inter-Ban communication using ZigBee protocol	
Number of nodes	Accuracy of determining the user position and ensuring to cover the operating range of the user	Relying on area's size, and sensor' range ability	7 nodes
Area's size	Accuracy, and homogenous performance of the localization system	Considering the width and length of area	8.60 m × 7.10 m
			6.5 m × 13.45 m
Height	Localization of nodes/energy	Nodes	~3.0 m
		Energy (Ubitag)	1.0 m
Sensor' Range	Coverage range of the sensors	Depending on sensor type	~5 m

There are several IEEE 802.15 standards that can be used to transmit data from sensors located on the user's body to a handheld device. The communication between sensors located on user's body and the device is known as inter-BAN communication. According to [17], some of these standards and the suitable range for the inter-BAN communication are: IEEE 802.15.1 protocol (Bluetooth) and IEEE 802.15.3 protocol (WiMedia) with a range less than 10 m, and IEEE 802.15.4 protocol (ZigBee) with a range less than 20 m.

4 Conclusions

This paper presented insights from the different lenses in examining the AAL literature and categorizing the technologies based on their selected spatial metrics. Challenges and trends in AAL technologies have become apparent and need to be considered by developers prior to designing spatial configurations for AAL environments and interaction design of such spaces (e.g. social interaction [38]). And one of the important challenges that the designers of an AAL environment must address is privacy. The reason is that in order to achieve context-awareness, adaptability and anticipatory behavior in an AAL environment, it needs to contain historical and current data about individual's daily activities and preferences [39]. The perception of privacy violation varies according to factors such as age, cultural background, and level of support an individual requires in order to live independently [40, 41]. Along with privacy comes security; an issue of how to secure the AAL environment from malicious attacks and hacks [42]. This paper aids developers in understanding the spatial design considerations for creating AAL environments for ageing populations, and contributes towards future research in spatial modeling and simulations for AAL.

References

1. Han, J., Pauwels, E.J., De Zeeuw, P.M., De With, P.H.: Employing a RGB-D sensor for real-time tracking of humans across multiple re-entries in a smart environment. IEEE Trans. Consum. Electron. **58**(2), 255–263 (2012)
2. Ando, B.: Measurement technologies to sense "users in the environment" for ambient assisted living. IEEE Inst. Meas. Mag. **15**(6), 45–49 (2012)
3. Cunha, D., Trevisan, G., Samagaio, F., Ferreira, L., Sousa, F., Ferreira-Alves, J., Simoes, R.: Ambient assisted living technology: comparative perspectives of users and caregivers. In: IEEE 15th International Conference on e-Health Networking, Applications & Services (Healthcom), Lisbon (2013)
4. Administration for Community Living, "Administration on Aging Aging Statistics," ACL (2012). http://www.aoa.gov/Aging_Statistics/. Accessed 14 October 2014
5. Wan, J., O'Grady, M.J., G. O'Hare, M.: Towards a scalable infrastructure for ambient assisted living. In: IEEE Third International Conference on Consumer Electronics, Berlin (2013)
6. Amaro, F., Gil, H.: ICT for Elderly People: « Yes, 'They' Can! » . In: *e*-CASE & e-Tech International Conference, Tokyo, Japan (2011)
7. AAL Joint Programme, "AAL Newsletter September," Ambient Assisted Living Joint Programme - Newsletter, pp. 1–2 (2013)
8. Aal, K., Ogonowski, C., Rekowski, T.V., Wieching, R., Wulf, V.: A Fall Preventive iTV Solution for Older Adults. Siegen, Germany (2014)
9. Aghajan, H., Augusto, J.C., Wu, C., McCullagh, P., Walkden, J.-A.: Distributed vision-based accident management for assisted living. In: Okadome, T., Yamazaki, T., Makhtari, M. (eds.) ICOST. LNCS, vol. 4541, pp. 196–205. Springer, Heidelberg (2007)
10. Alzheimer's Association, "Technology Improving Lives of People with Dementia." Memory Matters 14(1), 3 (2014)

11. Walsh, L., McLoone, S., Behan, J., Dishongh, T.: The Deployment of a Non-Intrusive Alternative to Sleep/Wake Wrist Actigraphy in a Home-Based Study of the Elderly. In: 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS), Vancouver (2008)
12. Adami, A.M., Pavel, M., Hayes, T.L., Singer, C.M.: Detection of movement in bed using unobtrusive load cell sensors. IEEE Trans. Inf Technol. Biomed. **14**(2), 481–490 (2010)
13. Kaluža, B., Gams, M.: Analysis of daily-living dynamics. J. Ambient Intel. Smart Env. **4**(5), 403–414 (2012)
14. Andrushevich, A., Kistler, R., Bieri, M., Klapproth, A.: ZigBee/IEEE 802.15.4 Technologies in Ambient Assisted Living Applications. In: 3rd European ZigBee Developers' Conference (EuZDC), Munich, Germany (2009)
15. Alemdar, H., Durmus, Y., Ersoy, C.: Wireless healthcare monitoring with rfid-enhanced video sensor networks. Int. J. Distrib. Sens. Netw. **2010**, 10 (2010)
16. Suryadevara, N.K., Chen, C.-P., Mukhopadhyay, S.C., Rayudu, R.K.: Ambient Assisted Living Framework for Elderly Wellness Determination through Wireless Sensor Scalar Data. In: Seventh International Conference on Sensing Technology (ICST), Wellington (2013)
17. Rashidi, P., Mihailidis, A.: A survey on ambient-assisted living tools for older adults. IEEE J. Biomed. Health Inf. **17**(3), 579–590 (2013)
18. Figueiredo, C.P., Gama, Ó.S., Pereira, C.M., Mendes, P.M., Silva, S., Domingues, L., Hoffmann, K.P.: Autonomy suitability of wireless modules for ambient assisted living applications. In 2010 Fourth International Confere on Sensor Technologies and Applications (SENSORCOMM), Venice (2010)
19. Estudillo-Valderrama, M.A., Roa, L.M., Reina-Tosina, J., Román-Martínez, I.: Ambient Assisted Living: A Methodological Approach. In: 32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS), Buenos Aires (2010)
20. Andò, B., Baglio, S., Lombardo, C.O.: RESIMA: an assistive paradigm to support weak people in indoor environments. IEEE Trans. Inst. Meas. **63(11)**, 2522–2528 (2014)
21. Spanoudakis, N., Grabner, B., Kotsiopoulou, C., Lymperopoulou, O., Moser-Siegmeth, V., Pantelopoulos, S., Sakka, P., Moraitis, P.: A novel architecture and process for Ambient Assisted Living - the HERA approach. In: 2010 10th IEEE International Conference on Information Technology and Applications in Biomedicine (ITAB), Corfu, (2010)
22. Culmone, R., Falcioni, M., Giuliodori, P., Merelli, E., Orru, A., Quadrini, M., Ciampolini, P., Grossi, F, Matrella, G.: AAL domain ontology for event-based human activity recognition. In: IEEE/ASME 10th International Conference on Mechatronic and Embedded Systems and Applications (MESA), Senigallia (2014)
23. Maurer, U., Smailagic, A., Siewiorek, D.P., Deisher, M.: Activity recognition and monitoring using multiple sensors on different body positions. In: International Workshop on Wearable and Implantable Body Sensor Networks (BSN 2006), Cambridge (2006)
24. Stelios, M.A., Nick, A.D., Effie, M.T.: An indoor localization platform for ambient assisted living using UWB. In: The 6th International Conference in Advances in Mobile Computing and Multimedia (MoMM 2008), Linz, Austria (2008)
25. Zouba, N., Bremond, F., Thonnat, M., Anfosso, A., Pascual, É., Mallea, P., Mailland, V., Guerin, O.: Assessing computer systems for monitoring elderly people living at home. In: The 19th IAGG World Congress of Gerontology and Geri-atrics, Paris (2009)
26. Pollack, M.E., Brown, L., Colbry, D., McCarthy, C.E., Orosz, C., Peintner, B., Ramakrishnan, S., Tsamardinos, I.: Autominder: an intelligent cognitive orthotic system for people with memory impairment. Robot. Aut. Syst. **44**(3), 273–282 (2003)
27. Association, Alzheimer's: Memory Matters. Technol. Imp. Lives People Dementia **14**(1), 1–8 (2014)

28. Barger, T.S., Brown, D.E., Alwan, M.: Health-status monitoring through analysis of behavioral patterns. IEEE Trans. Syst., Man, Cyb. **35**(1), 22–27 (2005)
29. Klein, M., Schmidt, A., Lauer, R.: Ontology-centred design of an ambient middleware for assisted living: the case of SOPRANO. In: Towards Ambient Intelligence: Methods for Cooperating Ensembles in Ubiquitous Environments (AIM-CU), 30th Annual German Conference on Artificial Intelligence (KI 2007), Osnabrück (2007)
30. AMI Conferneces, Smart Objects & Ambient Intelligence, 12–14 October 2005. http://www.ami-conferences.org/2005/. Accessed 5 December 2014
31. CITEC, Ambient Intelligence Group (2011). http://www.cit-ec.de/ami. Accessed 5 December 2014
32. Artesis University, AMBIT in Artesis University College of Antwerp (2013). http://www.artesis.be. Accessed 5 December 2014
33. Valero, Z., Ibáñez, G., Naranjo, J.C., García, P.: Am IVital: digital personal environment for health and well-being. Wireless Mob. Comm. Healthcare **55**, 160–167 (2011)
34. Ambient Media Association, "iAMEA - International Ambient Media Association" (2013). http://www.ambientmediaassociation.org. Accessed 5 December 2014
35. NTT Communication Science Laboratories, "Ambient Intelligence" (2008). http://www.brl.ntt.co.jp/cs/ai/index.html. Accessed 5 December 2014
36. Bruno, A., Salvatore, B., La Malfa, S., Marletta, V.: A sensing architecture for mutual user-environment awareness case of study: a mobility aid for the visually impaired. IEEE Sens. J. **11**(3), 634–640 (2011)
37. Alcantara, J.A., Lu, L.P., Magno, J.K., Soriano, Z., Ong, E., Resurreccion, R.: Emotional narration of children's stories. In: Nishizaki, S.-Y., Numao, M., Caro, J., Suarez, M.T. (eds.) Theory and Practice of Computation. PICT, vol. 5, pp. 1–14. Springer, Heidelberg (2012)
38. Alaoui, M., Ting, K.L.H., Lewkowicz, M.: The urge for empirically-informed design of social-oriented aal applications – the example of 2 aal projects. In: 5th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Information exclusion DSAI, Troyes, France (2014)
39. Friedewald, M., Da Costa, O., Punie, Y., Alahuhta, P., Heinonen, S.: Perspectives of ambient intelligence in the home environment. Telematics Inform. **22**(3), 221–238 (2005)
40. Cooka, D.J., Augustob, J.C., Jakkulaa, V.R.: Ambient intelligence: Technologies, applications, and opportunities. Pervasive Mob. Comput. **5**(4), 277–298 (2009)
41. O'Connell, P.L.: "Korea's High-Tech Utopia, Where Everything Is Observed," New York Times, 5 October 2005. http://www.nytimes.com/2005/10/05/technology/techspecial/05oconnell.html?ex=1286164800&en=4a368c49e8f30bd2&ei=5088. Accessed 28 December 2014
42. Friedewald, M., Vildjiounaite, E., Punie, Y., Wright, D.: Privacy, identity and security in ambient intelligence: A scenario analysis. Telematics Inform. **24**(1), 15–29 (2007)