

The Living Challenge of Ambient Assisted Living – a literature review

Ann Bygholm and Anne Marie Kanstrup

^aDepartment of Communication and Psychology, Danish Centre for Health Informatics, Aalborg University Denmark

Abstract

Ambient Assisted Living (AAL) is a rapidly evolving research and development area propelled by scarcity of health resources caused by an aging workforce and increase of citizens in need of health care and health assistance on a regular basis. This paper presents a literature review of the current state-of-the-art of AAL. The objective is to point towards methodological actions to be taken into account in AAL research on this basis. Searches were conducted in five research databases. The search identified 86 papers. 10 of these papers were review papers chosen for analysis. The analysis presents an overview of the current status of AAL within the following categories: technology, users, application domains, rationales, successes and challenges of AAL. The paper concludes that the living part, i.e. the everyday practice of people living with Assistive Technology, is the primary challenge to the field due to its complexity of people and practices challenging the technological development and use. This calls for methods that support research carried out in close co-operations with the living environment and facilitate the complexity of stakeholders within the use-domain in a constructive and innovative manner. Living Lab is discussed as a general example on such methods.

Keywords:

Ambient Assisted Living, Literature review, Assisted technology, Living Lab

Introduction

Ambient Assisted Living (AAL) is a rapidly evolving research and development area. This is due to shortage of resource in most Western countries facing an aging workforce and an increase in the number of citizens in need of health care and health assistance on a regular basis. AAL is increasingly influencing health care and health informatics and it is generally assumed that supportive technologies will be required to maintain an effective health care delivery in the future. This is reflected in international and national initiatives, e.g. the European Unions joint Programme in Ambient Assisted Living, ICT for Aging Well, and support to development and implementation of welfare technology. AAL is also addressed in the recommendation of the International Medical Informatics Association (IMIA) on education in biomedical and health informatics [1] as a necessary learning outcome for health informatics specialist just as e.g. usability engineering and cognitive aspects of information processing.

Despite the attention on AAL, it is difficult to define such domain due to its continuous technological development. Recent roadmaps from the European Union Commission concludes that “there is no common view about the precise definition of Ambient Assisted Living (AAL)” [2]. The scope of AAL is broad including a variety of Assistive Technologies

(AT), users and application domains. Thus the roadmap identifies three broad application domains (ALL for persons, ALL in the community, AAL at work) and five types of enabling technologies (Sensing, Reasoning, Acting, Interacting, Communication). A general description of AAL is that it encompasses “information and communication technology based products, services and systems to provide older and vulnerable people with a secure environment, improve their quality of life and reduce the costs of health and social care” [3]. The “living” perspective in AAL is broad and includes, according to the EU roadmap, AAL for people with different kind of living locations (family home, supported or sheltered housing/apartments, nursing home etc.), and on the move (mobile); AAL in the community; and AAL at work [2].

The purpose of this literature review is to present an overview of the current state-of-the-art of this broad field. The review serves as a basis for considering the methodological consequences of the challenges identified in the review. Furthermore, the summary of published research in this literature review provides a resource for other researchers and professionals working with AAL. The literature review is based on peer-reviewed literature.

Materials and Methods

The literature review was carried out via structured search in five research databases: ACM digital library, IEEE Explore, Google Scholar, ScienceDirect, and Scopus. These databases contain research in Information and Communication Technology (ICT), eHealth and electronic engineering. The search in the databases was structured via search strings of “AAL” OR “Ambient Assisted Living” OR “Assistive Technology” OR “AT” OR “Welfare Technology”. Since the ambition is to present an overview of current AAL research, the search was limited to papers published within the recent six years period 2008 – 2013.

86 publications were identified. Among these we selected review papers for analysis. This included 10 papers reviewing a large amount of AAL literature.

The reviews used for analysis cover a variety of perspectives. Some of the review papers focus exclusively on video based technology [3], [4], a majority of the reviews focused on AAL in the home of elderly [5], [6], [7], [8], [9], [10], [11] and one review focused specifically on ethics [12]. One of the reviews aim at presenting concrete projects from around the world within the AAL area [5], others focus specifically on presenting the technologies involved [10] [11] and developing a taxonomy of different levels of operation [4], and others again focus on explaining different types of service categories [6].

In our review, being a review of reviews, we focused on revealing the main methodological points to be learned from current studies.

The analysis was carried out by readings of the selected papers and organizing findings within the following categories:

- Users (who are the users presented in the literature?)
- Use environments (what are the use environment studied in the literature?)
- Technology (what is the primary AAL technology in the literature?)
- Rationale (what is the expressed rationale for AAL in the literature?)
- Current status (how does the literature present the current state of AAL searched for in presented successes and challenges?).

Results

In general, the literature review reveals a series of minor studies, technological trials, and descriptive studies. Consequently, the literature does not present contours of theoretical frameworks or conceptual models for AAL. As such the literature resemble the broad field of AAL characterized by a lack of common view of AAL [2]. However, the literature does reveal current priorities, trends and general challenges of AAL. These are summarized below and elaborated in the subsequent sections:

- A primary focus on elderly citizens as users
- A primary focus on the home of elderly citizens as use environment of AAL
- A primary focus on monitoring technologies
- A primary economic rationale of AAL
- It is a success when technology works as intended in the research setup.
- The overall challenge is the “living” part of AAL, which is characterized by unpredictable and complex application environments, users and technologies to be integrated in an ambient assistive manner

Users

Primary users are elderly people as the main target group of AAL and “vulnerable people” [3], “cognitive impaired people” [4], and “disabled” [5] as additional potential target groups.

A complexity of many stakeholders is presented in two of the reviewed papers including family caregivers, designers, health care professionals, decision makers all with different needs when it comes to technology and information [6], [7]

Use environment

The use environment of all the reviewed papers is the home of the elderly – term often coined “smart home”. Thus, the literature presents a more narrow perspective on AAL than the one defined by the EU commissions including on the one hand different types of living locations such as the family home, home for seniors, supported apartments, nursing homes and on the other hand community- and work environments [2].

Technology

The primary technology under development and studied in AAL literature is monitoring technology in a span from video cameras and computer vision systems [3], [4] wearable technologies and assistive robots [5] and an overweight of sensor

based technologies [6], [7], [8], [9], [10]. Also this is a narrower picture of AAL than the one defined by the EU commissions roadmap [2]. Some of the review papers address this narrowness and call for technology that prioritize social connections, assistive communities, and human participation [9].

Rationale

A primary rationale of AAL presented in the literature is economic with the ambition of reducing care costs [3], [4], [5], [7], [9].

Another rationale presented in the literature is improved health via technology that can “keep elderly people from the negative consequences of an emergency or potentially dangerous situation” [6]. This prevention of emergencies is presented together with rationales of “improving the quality of life” [8], safety, wellness and social connectedness [10], independence and self-determination [12].

Successes

In correlation with the economic rationale of AAL, a central success is a decrease of hospital admissions [5], [7], [9]. This economic success is a vision of AAL. However, none of the studies present evidence of the effects of AAL on health outcomes [8].

In correlation with the exploring character of the field of AAL, it is a field characterized by a series of minor studies and technology trials [7]. Success is estimated on the basis of the lack of failure on the technical device level [4], [10]. Also technological reliability is a vision, not a reality of AAL. As presented by [4] “there is still a long way to go to achieve off-the-shelf products”.

Challenges

The literature identify a series of challenges from technical maturity and lack of standards [3], [4], [9], complex technical networks, usefulness and acceptance of Assistive Technologies by users [6], [7], [8], [12]. It is a general conclusion in the literature that the overall challenge is the technology’s ability to meet the complexity of the real life of use – the “living” part of AAL. The complexity of AAL is presented as “beyond pure technical development” [6]. There is a need for understanding the living part of AT and move beyond assumptions that users will accept and adopt AAL without hesitation or training [5], [6] [8]. Consequently, several papers call attention to the need to focus on “interdisciplinary work between all stakeholders and the service engineers” [6]. The complexity of stakeholders is emphasized as important and stakeholder participation is presented as a current missing link in AAL research and development [7], [8], [12]

Discussion

The above mentioned challenges as well as the roadmap from the European union points to a need for methodological considerations on how to design and implement AAL: “All stakeholders should be aware that user involvement is the key for a technological, innovative and business success in AAL – from the initial concept through systems design and integration to the prototypes and business models” [2] However, user involvement is not a straight forward issue in this context. As mentioned above the main users can be identified as “elderly

people”, but this is a very broad group that might very well include more differences than similarities in the requirements to AAL. Besides, there are also the surrounding people (relatives and professional caregivers) with their specific needs and requirements to AAL. Most of the papers reviewed have as a basic premise that AAT in general will make a positive improvement in the life of the elderly people. AAL is thus supposed to increase the personal autonomy and quality of life [4] allow people to live independently at home [3] [8] assist people with reduced physical functioning and also resolve social isolation [5] [10] by extending the time older people can live in their own home [9] help detect signs of illness [10] and so on. Whereas knowledge on actual users, use situations and use environments more belongs to the challenges that need to be addressed in the future [5] [8] [9].

A general issue related to acceptability of AAL and mentioned in several of the papers [3] [5] [8] [12] is the tension between privacy and security. As mentioned in [3]: “The dilemmas arise from the impossibility of weighing up the benefit of surveillance systems and the potential loss of privacy”. Part of the dilemma might be handled as a question of different kinds of data protections, but there is no general true answer to this dilemma and the issue has to be solved as specific solutions for specific users in specific environments.

The overall challenge is as mentioned before the technology’s ability to meet the complexity and multiplicity of real life. One methodological approach aimed at handling this need for cooperation among relevant stakeholders is Living Laboratories [2]. Living laboratories, Living lab from now on, refers to a setting that allows for innovation and cooperation between the various participants (different types of users, designers, researchers etc.) involved in development of e.g. AAL. The purpose of living labs is thus to “enhance innovation, inclusion, usefulness and usability of ICT and its application in society” [13]. The concept of a living lab refer both to an environment that has different types of technology installed and a methodology that aims at supporting the cooperation and co-creation among the different participants involved [14]. Thus living labs support research in context and co-creation with users and are at the same time a test bed for different types of technologies [15] Different forms of Living lab exist, sometimes a natural setting is turned into a lab like a whole city or a real home and sometimes a lab is turned into a natural setting like when people move to a smart house. Living labs does not provide a formula for how to design for the complexity of life but represent an ambition to embrace the complexity of the real life when developing new technologies.

Conclusion

AAL is a broad field challenged by the complexity of problems involved in assisted living with technology. The current trend within AAL focus primarily on technology designed for elderly people living at home with monitoring technology. However, European Roadmaps and the literature highlight that AAL has a wider scope and include a variety of people interacting in complex networks including communities and work on a daily basis. Thus, AAL has the potential to expand beyond monitoring technologies. The literature call for expanding the current trend of AAL toward a focus on the power of human beings and their ability to support each other through technological cooperation’s.

AAL is driven by visions about costs and health improvements. There is no evidence of the cost effectiveness and health improvements of AT. The field AAL is characterized by test of novel technologies where reliability challenges research and development.

Research implications from this literature review call attention to several aspects:

- the maturity of AAL and its importance for research and development, i.e. preparing AAL to reach a maturity that makes it possible to be tested in living environments is an important research focus. This includes the functionality of AALs but also the integration of multiple applications in AAL networks.
- methods that can facilitate research and development in the complex living of AAL. The complexity is a challenge to knowledge and resources of research and development and call for methods that can provide understandings of complex everyday living and innovative development of new practices for assistive living in a resource wise manner.
- A need to clarify the role of AAL stakeholders. It is a central challenge to engage stakeholders in AAL research and development. Methodological development on stakeholder participation should include a clarification of how best to set a team for AAL research and development.

References

- [1] J. Mantas, E. Ammenwert, G. Demiris, A. Hasman, R. Haux, W. Hersh, E. Hovenga, K.C. Lun, H. Marin, F.Martin-Sanchez, G. Wright Recommendations of the International Medical Informatics Association (IMIA) on Education in Biomedical and Health Informatics, *Methods Inf Med* 2010, no 49, p 105-120
- [2] G. Van Den Broek, F. Cavallo, og C. Wehrmann, *AALLIANCE ambient assisted living roadmap*, bd. 6. Ios Press, 2010.
- [3] F. Cardinaux, D. Bhowmik, C. Abhayaratne, og M. S. Hawley, «Video based technology for ambient assisted living: A review of the literature», *J. Ambient Intell. Smart Environ.*, bd. 3, nr. 3, s. 253–269, 2011.
- [4] A. A. Chaaoui, P. Climent-Pérez, og F. Flórez-Revuelta, «A review on vision techniques applied to human behaviour analysis for ambient-assisted living», *Expert Syst. Appl.*, bd. 39, nr. 12, s. 10873–10888, 2012.
- [5] M. Chan, D. Estève, C. Escriba, og E. Campo, «A review of smart homes—Present state and future challenges», *Comput. Methods Programs Biomed.*, bd. 91, nr. 1, s. 55–81, 2008.
- [6] W. Ludwig, K.-H. Wolf, C. Duwenkamp, N. Gusew, N. Hellrung, M. Marschollek, M. Wagner, og R. Haux, «Health-enabling technologies for the elderly—an overview of services based on a literature review», *Comput. Methods Programs Biomed.*, bd. 106, nr. 2, s. 70–78, 2012.
- [7] B. Reeder, E. Meyer, A. Lazar, S. Chaudhuri, H. J. Thompson, og G. Demiris, «Framing the evidence for health smart homes and home-based consumer health technologies as a public health intervention for independent aging: A systematic review», *Int. J. Med. Inf.*, 2013.
- [8] G. Demiris og B. K. Hensel, «Technologies for an aging society: a systematic review of “smart home” applications», *Yearb. Med. Inform.*, bd. 47, nr. Suppl 1, s. 33–40, 2008.
- [9] H.Sun V. De Florio, N. Gui, og C. Blondia, «Promises and challenges of ambient assisted living systems», i *Information Technology: New Generations, 2009. ITNG’09. Sixth International Conference on*, 2009, s. 1201–1207.

- [10]M. Bal, W. Shen, Q. Hao, og H. Xue, «Collaborative smart home technologies for senior independent living: a review», i *Computer Supported Cooperative Work in Design (CSCWD), 2011 15th International Conference on*, 2011, s. 481-488.
- [11]V. Venkatesh, V. Vaithayana, P. Raj, og R. Amirtharaj, «An Ambient Assisted Living for Smart Home to Wealthy Life: A Short Review», *Res. J. Inf. Technol.*, bd. 5, nr. 1, s. 1–11, Jan. 2013.
- [12]S. A. Zwijsen, A. R. Niemeijer, og C. M. Hertogh, «Ethics of using assistive technology in the care for community-dwelling elderly people: An overview of the literature», *Aging Ment. Health*, bd. 15, nr. 4, s. 419–427, 2011.
- [13]Eriksson, M., Niitamo, V.P., & Kulkki, S. State of the art in Utilizing Livina Lab approach to user-centric ICT innovation – a European approach *Lulea Cent. Distance-Spanning Technol. Lulea Univ. Technol. Swed. Lulea Online Httpwww Cdt Ltu Semain PhpSOALivingLabs Pdf*, 2005.
- [14]Bervall-Kåreborn, B., Eriksson, C.I, Stålhbröst, A, & Svensson, J. A Milieu for innovation – Defining Living Labs, in *2nd ISPIM Innovation Symposium, New York*, 2009
- [15]Følstad, A. Living Labs for Innovation and Development of Information and communication technology: A literature review, *EJOV Electron. J. Virtual Organ. Netw.*, vol. 10, 2008

Address for correspondence

Ann Bygholm, hum@aau.dk