

Technological and cognitive roadmaps for Ambient Assisted Living

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Abstract

As a result of the continuous increase of ageing population, a growing number of frail and impaired people (both in physical and cognitive functions) need assistance and pose dramatic challenges for the health and welfare systems. The projects in the Ambient Assisted Living (AAL) field aim at developing intelligent systems able to provide personal assistance to elder and impaired people, allowing them to continue living in their familiar environment and preserving as much as possible their independence. AALIANCE is one European FP-7 project developed in the AAL context established for creating a common vision of AAL and developing a roadmap of future steps and projects on the way to AAL systems. In this paper the AALIANCE roadmap document is presented and the main trends towards AAL are addressed, both from technological and human-centered (psychological, cognitive) points of view.

The AALIANCE Project and the AAL Roadmaps

The industrialised world is experimenting a spectacular increase of ageing population, mainly consequent to the baby boomers generation crossing the threshold of retirement. Such a change in the demographic structure will affect all aspects of the life, including a larger number of frail and impaired people (both in physical and cognitive functions). In particular the risk associated with cognitive impairments is raising with the age and goes with elevated social and economic burdens relevant to its chronic nature and to the progressive loss of autonomy.

At the same time, while representing dramatic challenges for the health and welfare systems it will offer innovation and business opportunities for technology providers, fostering, among others, the development of ICT-enabled assisted living paradigm or "Ambient Assisted Living" (AAL). AAL refers to intelligent systems of assistance and represents a paradigm shift – in society as well as technology – that will walk hand in hand with "human centered computing", where the emphasis is on user friendliness, situation awareness, distributed service support for human interaction.

The AAL system through adaptive and distributed user-system interfaces, body and environment sensor network and AI subsystems, is designed to be able to infer about the activities of daily life (ADLs) the user is carrying out and about the context in which such activities are taking place.

In societal terms, AAL is focused to enable the containment of the overall cost of assistance, offering truly acceptable and usable solutions to the growing need for personal assistance, mainly related to the steadily growing cohort of elderly people, while increasing their independence and ultimately the quality of their lives.

In this context AALIANCE ("The European Ambient Assisted Living Innovation Alliance"), a European FP7 project ended in 2010, had the goal to create a common vision of AAL that provides and defines the necessary future R&D steps and projects on the way to AAL. It aimed at developing such a roadmap and strategic guidance for short-, mid- and long-term R&D approaches in the context of AAL. In this paper the AALIANCE Ambient Assisted Living Roadmap document (Van Den Broek et al., 2010) is presented, addressing the main trends towards AAL, both from technological and human-centered (psychological, cognitive) points of view.

The Roadmap starts with the analysis of the main trends towards AAL, analyzed from a demographic, economic and technological point of view, and the barriers for their deployment, identified for each stakeholder of AAL, i.e. users and caregivers (primary stakeholders), organizations offering services (secondary stakeholders), organizations supplying goods and services (tertiary stakeholders) and organizations analyzing the economical and legal context of AAL (quaternary stakeholders). The needs of elderly and disabled people were studied and identified considering the two fundamental aspect/expectations of the human, that are the *autonomy* and the *independence* in different contexts of daily life.

Starting from these reflections, three main application domains of AAL technologies were identified: AAL for Persons, AAL in the Community, and AAL at Work. These areas reflect the three fundamental contexts of human daily life, that are the personal and health care considered from the physical and cognitive aspects; the participation to the Community activities; the work considered not only as means of economical subsistence but also as instrument for the expression of the own personality, attitudes and self-fulfillment.

Unfortunately, physiological deficits and pathologies invalidate the autonomy and the independence of elderly and impaired persons in these domains, causing problems for both the single subjects and their families and also for the Community that should satisfy an increasing request of services and support. Advanced technologies (ICT,

Table 1: Application Domains defined in AALIANCE AAL Roadmap.

AAL APPLICATION DOMAINS		
4 Persons (@home; @mobile)	@ Community	@Work
- Health, rehabilitation, care	- Mobility	- Collaboration,
- Safety and security	- Social Inclusion	cooperation
- Activity management/cognitive support	-Entertainment and Leisure	
- Autonomy / physical support		
- Person-centric services		

Ambient Intelligence, Ubiquitous and Service Robotics, etc.) can be useful tools to help directly elderly people in their ADLs and to support caregivers and sociomedical workers in their jobs.

The AAL Roadmap describes some realistic scenarios related to the single application domain in which ICT and technologies can contribute for helping and guaranteeing people independence (see Table 1). Then technologies and innovations that should be implemented to accomplish these scenarios have been identified describing current technologies and the technological objectives foreseen for the short-, mid- and long-term and how academic and industrial S/T researches should evolve to obtain them. This analysis was carried out looking in particular to all main functionalities that compose the AAL integrated systems: sensing, reasoning, acting, interaction, communication, power supply (Table 2).

Furthermore, the document delineates possible directives for the integration of technological support and contribute in the service settings supplied by public and private service providers (novel service models) and also economical and legislative actions that the society should perform for introducing the AAL technologies in the community guaranteeing and preserving at the same time the safety and the welfare of all citizens.

From AAL Roadmap to the Scuola Superiore Sant'Anna research trends

The AALIANCE AAL Roadmap has been considered by the European Commission as good guidelines for the development of novel European S/T researches so that the Work Programme 2011 Cooperation, Theme 3, says that the next Coordination frameworks developed in the context of the Challenge 5, Objective ICT-2011.5.4 "ICT

for Ageing and Well-being", Target C, should "...take into account work already started under the AALIANCE innovation platform (ref. <http://www.aaliance.eu>)" (European Commission, 2010).

Several research groups are using the AALIANCE AAL Roadmap to address their researches in the AAL fields and service robotics in order to design and develop technological solutions useful and exploitable in society to support elderly and disabled people in their ADLs. In particular the Scuola Superiore Sant'Anna (Pisa, Italy) is carrying out several researches related to AAL and service robotics making reference to AAL Roadmap.

In the context of the calls for experiments organized by the ECHORD Project funded by FP7, the Scuola Superiore Sant'Anna is involved in ASTROMOBILE project (Cavallo et al., 2010; Nepa et al., 2010). This project aims at designing an assistant robot, starting from the robotic platform SCITOS G5 (MetraLabs GmbH), able to provide some services to elderly people (such as monitoring the presence at home and the health status, connecting the user with outside people, reminding him/her about drugs to be taken and events, etc.), to cooperate with users in executing ADLs at home, to interact with them adopting strategies similar as much as possible to natural human ones, and that can be considered usable and acceptable by this particular target of users. The ASTROMOBILE system foresees the integration of the mobile robot with a sensor network and an ambient intelligence infrastructure. During this project an extensive experimentation in realistic indoor environment, that is DomoCasa living lab, and with real elderly people will be carried out.

The project follows a User Centered Design methodology and so it will involve the older persons, through meeting, interviews and other surveys, since the

Table 2: Summary of the main functions and enabling technologies described in AALIANCE AAL Roadmap.

MAIN FUNCTIONS AND ENABLING TECHNOLOGIES	
Sensing	New sensors (health parameters, environment, localization, etc.) Sensor networks
Reasoning	Ontologies Event stream processing Probabilistic reasoning Event prediction
Acting	New actuators Home robots and mechatronic devices
Interacting	Multimodal, natural, persuasive interfaces
Communicating	New protocols and standards for communication network

beginning of the project, in order to address the design of the ASTROMOBILE system (aesthetics and appearance of the robot, way to carry out the domestic services, human-robot interfaces, etc.) for being really suited for elderly people and satisfying the users expectations.

RITA is a different project, developed in the context of Tuscany region. It has been conceived by researchers of Scuola Superiore Sant'Anna coming from different research fields, robotics and law, that are designing novel ICT technological solutions to support and monitor elderly people living alone, and are investigating how these technologies can be exploited and inserted in the context of socio-medical services supplied from public regional providers, and how to deal with both legal and socio-ethical aspects.

For this project a sensor network and ambient intelligence infrastructures will be developed to monitor health status of old subjects, to localize them both indoors and outdoors, to monitor the domestic environments, to recognize potentially dangerous events and to activate alert actions for providing promptly help to the elderly user. All these technological tools will be designed according to indications provided from real elderly people, their caregivers and socio-medical workers, involved through the socio-medical service provider of Pisa's areas, that subsequently will also test the systems.

Moreover, the Scuola Superiore Sant'Anna is carrying out other researches oriented to the robotics and ICT technologies for "Ageing Well" because strongly believes that the technology can help people to live better and is so advanced to be ready to be implemented in real life because acceptable and safe.

Towards a cognitive roadmap

In AAL, products and services, provided by a heterogeneous set of disciplines, are based on selected standards that allow the interoperability of applications and designed in a user-centered way. The main objectives that should direct such a research effort are: from a personal view, to allow impaired people to continue living in their familiar environment; from a social point of view, to reduce assistance costs.

In the first phase technological aspects have been mainly addressed. There are, however, a number of issues to be raised from a human-centered perspective: psychological, cognitive, social, etc. In particular, in the present section we would like to emphasize some psychological and cognitive points that should be integrated with the technological guidelines in the next developments. Such approach belongs to the cognitive science domain, because the contribution of different disciplines is needed.

Acceptance and attitudes

The first implication is about the *psychological acceptance* of an artificial companion. In a previous work (Greco, Anerdi, Rodriguez, 2009) we conducted a preliminary empirical study in order to assess the acceptance of an animaloid robot during a simple

interaction session with cognitively impaired elders. Starting from this study we claimed that such acceptance should be considered as a multifaceted attitude, where affective, cognitive, and conative aspects have equal importance. In our opinion, the next steps in the cognitive slope of a roadmap firstly include psychological surveys planning, concerning the acceptability, and possible implementation approaches,

- (i) of a pervasive monitoring of daily activities,
- (ii) of the presence of an AAL system,
- (iii) of interaction with such a system.

In fact, the presence of a continuous monitoring system may give some individuals a suffocation feeling; the possible negative effects of other components of an AAL system must also be carefully scrutinized. And even if the system is accepted, misunderstandings or deceptions can occur about its intended purpose or use. Willingness to interact also should not be taken for granted.

The methodological tools for these surveys include standard interviews, questionnaires, (directed also to relatives), systematic observation sessions, related assessment tools, and also new pilot experimentation on the field.

If this first line of inquiry is just aimed at collecting information, a second line to be developed concerns tools aimed at attitude formation and change. A human-centered AAL system must be part of a *positive attitude system*. This can be developed by enhancing in potential users:

- (i) a correct *knowledge* about the system, not only from the technical point of view but also concerning its general philosophy and purposes;
- (ii) a positive *feeling*, obtained from a well-done affective computing, able to correctly recognizing user emotions, and to behave in an emotionally sensible way;
- (iii) a motivated *intention* to use the system.

We claim that this attitude can only be developed through *interaction*, where the system and the user progressively adapt themselves and each other in order to achieve the final state, where the user has built an increasingly positive attitude, as explained above, and the system has built an increasingly refined user model.

User model

The *user model* is a key concept in this context. It can be developed as a set of general frames, available at the start as a standard toolkit, to be tailored and customized on the way to the user needs, through *interactive learning*. Each frame should include general expectations concerning a different area, belonging to the different enabling technologies for AAL. In order to establish these expectations, an assumption of normality could be the right starting point. In other words, the model could start with the default assumption that a user has a particular skill unless the contrary is proved, possibly in test situations.

We shall consider now some technological aspects specified by the Roadmap (see Table 2). The next mentioned functional components should neither be conceived as standalone mechanisms carrying out

computations for their own use, nor just as replacement or improvement devices for faulty intellectual processes and resources. Each of them, instead, must be designed as a true subsystem devised to interact with the user in order to build a personalized model of this particular person.

Sensing

Sensors are planned to be placed everywhere, in-body or on-body, in-appliance or on-appliance, or in the environment (see Figure 1). The user also, on his part, has a sensing system, and both systems should interact. In the technical Roadmap much attention is correctly posed to the requirement that sensors be seamless, integrated, less disturbing as possible. It is also important to realize, however, that the huge potential quantity of information conveyed by a complex network of sensory systems is not seamless from the cognitive point of view, and that more and more complex links with high-level processes are needed, so that truly relevant features in context are selected. The fundamental problem here is how to shape a potentially very rich model to be “aware” of the personal limitations of a specific user.

Reasoning

It concerns aggregating, processing and analyzing data, transforming it into knowledge within different and often cross-connected spaces (body, home, vehicle, public spaces). These processes, in fact, may assume a function that can integrate some well known deficits in verbal and visuospatial cognitive capabilities: attending relevant task aspects and inhibiting irrelevant ones, dealing with cognitive workload in complex environments (Newell et al., 2008).

Higher levels of reasoning, as illustrated in Figure 1, concern categorization of user activities and situation recognition. To this purpose, a cognitive task analysis may be useful to help identify critical steps in action performance. Here, again, the aim is not to reach a representation of the ideal performance, but exactly

recognizing where the user deficits lie. And this should be done dynamically, because such deficits are not fixed once for all, but can change with time and contexts.

Acting

It is based on sensor-motors (e.g., cognitive robots) and actuators that, based on their perception of the environment, on behalf of their users and on information gathered by some other device and/or background knowledge, could perform concrete actions. These agents should be able to learn the personal habits of the user, that make him/her different from other users, and also individual styles, that often make the same person to perform the same thing differently. It should be able also to detect which actions are performed as automatic or controlled processes.

Interacting and Communicating

An intelligent interaction with systems and services is devised, in order to cope with the abilities of users. Sensors and actuators are connected to one or more reasoning systems that in turn might be connected (even dynamically, e. g. a person moving from home to a vehicle and then to some public space) to other reasoning systems, possibly with their own sensors and actuators.

One important point concerns here the development of suitable interfaces, which may be difficult for cognitively impaired people. It may be obvious that an interface should be as more humanlike as possible. This is not only because elders often lack technical or computing systems knowledge, but also because they should not consider it as a mechanical device, but as a tool that works similarly and extends their natural and usual communication with people relevant in their life. In this vein, as an example, the development of gesture-based commands is worth to be pursued. It can be used, in part, also as a mediating tool for establishing a real communication system with family.

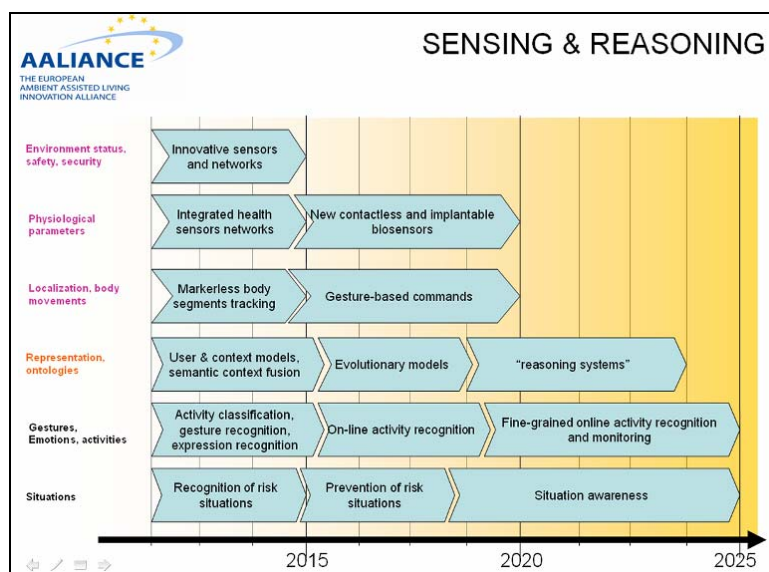


Figure 1: Sensing and Reasoning Roadmap (Van Den Broek, Cavallo, Wehrmann, 2010).

Conclusion

In this paper we have presented the AALIANCE roadmap final document, that addressed some technological trends and established shared guidelines towards building and experimenting realistic Ambient Assisted Living systems, designed to support elders and cognitively impaired persons during their everyday life. We outlined also some basic elements of a cognitive science framework for a future extension toward a cognitive roadmap. This short analysis is, of course, just a starting point, and it does not claim to be systematic and exhaustive. Many details are also being developed in other research groups (e.g. Langdon, Persad & Clarkson, 2010).

The key points we identified here for such an extension are: a methodology that involves users through inquiries aimed at assessing the acceptance of AAL systems, in principle and in some potentially uncomfortable details; the establishing of both a positive attitude in the user and of a sound user model in the system, via interactive learning. We stressed the requirement that such a model be able to autonomously and dynamically detect user inadequacies and to learn user practices. The interaction interface should give the feeling of a natural communication with significant people, like family members. Ultimately, we did not mention about it, but it goes straightforward: a method of performance testing has to be created in order to ascertain the efficacy of the proposed solutions.

Acknowledgments

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