

Assisted Living Systems for Elderly and Disabled People: A Short Review

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Abstract: *The number of elderly people living alone in their homes is permanently growing in the whole western world. Because of the deteriorating capabilities to sense and interact with the environment, such as memory, eye sight, hearing and mobility, the ageing populations often live with significantly degraded life quality. Many also suffer from chronic diseases that require medical treatment and periodical examinations.*

Different Assisted Living Systems have been proposed to cope with the problems. The goal is to enable the elderly people to live longer in their preferred environment, to enhance the quality of their live and to reduce the expenses of the public health care. The Assisted Living Systems are based on a lot of sensors, actuators and multimedia equipment, providing for the autonomy of people and assisting them in carrying out their daily activities together with available interaction with remote relatives and friends.

The applied approaches and implementations are specific that limit the dissemination of the results between the object oriented groups. Besides, most of the projects require considerable funding for implementation.

For the time being and especially for some countries with lower Gross Domestic Product, the efforts may be directed to creation of low-cost assistive systems performing some basic tasks, related to the need and health status of the living alone adults or disabled people, e.g. automatic fall detection and signalization, as well as instantaneous monitoring the photoplethysmographic signals together with permanently available communication interface between the caregiver and the user.

Keywords: *Ageing populations, Ambient assistant living, Supporting of elderly, Safety of disable people, Technologies for care monitoring and social communications of elderly in home environment.*

Trend of the world population

The elderly people are the faster growing segment of the world population since the end of the last century. In 2035 a third of the Europeans will be over 65 years old [2, 5, 6]. The predictions are that the percentage of people with disabilities will dramatically grow between 2006 and 2031. The number of citizens aged between 75 and 94 years with a profound restriction will rise steadily until 2021 and then will escalate sharply [11]. Similar

increases are predicted worldwide. People over age 65 in the United States is expected to hit 70 million by 2030, doubling from 35 million in 2000. It has been reported [20] that the number of elderly people living alone in Korea has increased by 100% during the last ten years. According to data published by the Bulgarian National Institute of Statistics [27], the relative part of the population older than 65 years has reached 23.5%. The mean age still allowing the basic daily activities to be performed without difficulties was about 63 years for men and 67 years for women in 2009.

In the coming decades, the expenses on pensions and long-term health care are anticipated to increase by 4-8% of the Gross Domestic Product [7]. As a result, objectives about cost reduction in the public health services will arise, together with the wish of elderly for independence and continuous living in their own houses [6].

Recently, some concerns have been expressed in the most developed countries about their ageing populations [21]. Because of the deteriorating capabilities to sense and interact with the environment, such as weakened memory, eye sight, hearing and mobility, elderly people often live with significantly degraded life quality [20]. Usually they forget to take the prescribed drugs, sometimes do not turn-off the used electric appliance. The statistic shows that 30% of the old people fall at least once a year and 75% of these events are responsible for accidental death [6]. That is why the risk of fall increases the anxiety and the depression in the elderly. Many suffer also from chronic diseases that require medical treatment and periodical examinations.

Different initiatives have been taken to cope with the problems. One of the approaches, the so called Assisted Living Systems (ALS) became a challenging task that gained great importance in supporting the elderly people living alone in their homes and needing care taking [16, 24]. The offered indoor assistance is aimed to enhance the autonomy and quality of life of the user and to bring to its social reinforcement. The results in this area have a quick public impact.

Requirements and engineering aspects of ALS were discussed by many authors. Many technologies have been investigated for automatic fall detection; bed and chair pressure detection; vibration analysis; video monitoring; sensor devices like accelerometers, tilt sensors, gyroscopes; 'watch-type' and belt-worn' design [6].

Ambient Assisted Living (AAL) is an initiative from the European Union [15], which is aimed to improve the care of the ageing population by implementing Info-Communication Technologies. The program intends to increase the autonomy of elderly by assisting them in carrying out their daily activities. The goal is to enable the people to live longer in home environment, to improve the living conditions and to reduce the expenses of the public health care.

Assistive systems: state of art

Some studies deal with the services that have to be addressed to elderly having cognitive problems, e.g. Alzheimer disease [5, 11, 29]. The systems are expected to be capable of integrating several subsystems developed by different manufacturers [23]. They must be easily adaptable to a particular user, who very often has limitation and handicaps. Its location is identified by radio frequency technology, including sensors in many places at home as well as other sensors fixed on the user's body [23]. Messages are generated e.g. for reminding him to take his pills. The systems integrate the elderly people, their relatives, the health service

provider and the data center. Speech recognition techniques and Bluetooth communication are planned for implementation.

The major industry project is perhaps the *age-in-place* advanced smart-home system of Intel Corporation [20]. It aims to help elderly people with Alzheimer's diseases, by integrating four major technologies: sensors, home networks, activity tracking and ambient displays. The sensors located in the home environment perceive the locations of the people and the objects in the home. The home network uses a combination of motion sensors, cameras, contact switches and magnetic switches to keep track of the activities and to display the environment.

Bamis et al. [4] interpret sensors, middleware and behavior interpretation mechanisms as the three main components that aim to make effective monitoring and assistive services a reality.

Holtzinger et al. [15] draws attention to the user interfaces, which should be easily accessible, but also useful, usable and enjoyable for people.

In another paper Holtzinger et al. [17] concluded that the engineers highly underestimate the power of appropriate knowledge on semiotics and demonstrated how a universal access to the technology can be emphasized.

Alexander et al. [1] pointed out that if the old people cannot live at home, the option might be homelike ambience with assisted living facilities rather than a more restrictive nursing home environment. The authors reported results of an expert review on data displays of sensor system used for monitoring the functional abilities in elderly and for detecting their functional decline. The system includes sensors located in the bathroom, bedroom, closet, front door, kitchen, living room and shower. The sensor data displays are rated highly for the ample contrast on the main display components. The authors found as important subject-matter the development of help screens to train users in using the information system.

The smart in-home monitoring system of the University of Virginia [32] focuses on data collection using a set of low-cost, non-intrusive sensors. The information was logged and analyzed in an integrated data management system that is linked to Internet. The system essentially accumulates information in a passive manner and does not directly interact with elderly people.

A smart medical home prototype was elaborated at the University of Rochester [31] consisting of infrared sensors, computers, bio-sensors, and video cameras. The key services are the medical advisory, which provides a natural conversational interface between the patient and health care expert, the motion and activity monitoring, and the personal health care record for consumer-provider decision support.

Hong Sun et al. [18] assert that most of the current efforts for addressing the elderly people by AAL still do not fully express the importance of the social connections and activities. They argue that the importance of smart devices is overemphasized while the human interaction is neglected. For the most part, the AAL systems consider the elderly as people, who are weak and passive, assisted by others. Actually, some of them can still contribute to the society through their valuable experience. Therefore, the people's willingness to participate in these systems needs to be investigated and encouraged.

The Integrated Project *SOPRANO* [19] aims to extend the time that people can live independently in their home environment with increased autonomy, self-confidence and enhanced security. The necessary technologies include products and services that enable persons to perform tasks or functions at a level similar to earlier experience.

Aviles-Lopez et al. [3] tested in laboratory a platform intended to be implemented in nursing home. The research in the AAL area is directed to support elderly with both physical and mental declinations, such as diabetes, arthritis, senile dementia, Alzheimer and heart-related diseases coming with the natural aging process. Possible alternatives and innovative tools were discussed in the context of improving the users' lifestyle by helping them maintain certain degree of independence. The concept of the AAL system is based on the appearance of new types of mobile and embedded computing devices, as well as on the developments in wireless networking, smart sensors etc. Some system characteristics are invisibility, mobility, context awareness, natural communication with users, adaptability. To be tracked and identified within the space, the users have to wear a digital tag that can take the form of watch, purse, glasses or other embedded in clothes accessories. If the elder user has suffered a fall, the system must alert the nursing home people without requiring the user's request. As the elderly are reluctant to use mouse, keyboard and read text on screen, a new approach must be taken when communicating messages. Possible approaches are the use of voice commands and visual components. Data about blood pressure, sugar levels etc. should be acquired, derived and communicated in fast and reliable way. The authors reported for the so called sentient visor that can represent something like tablet computer or smartphone. The user starts the interaction by touching with it an object or area of interest. An exemplary implementation was described for the case when many different drugs have to be daily taken. Sometimes the elderly forgets to do it or even worse, he takes the same amount of pills twice. Therefore, a better approach is when the user attaches the tag to each bottle to look for the proper dose. In such way the physician may also change the dose after some medical examinations are conducted via phone. Other intelligent components of the care monitoring are the closed circuit camera system and the sensors with embedded accelerometer. They enable the caregiver to track the user's walk around the rooms and to perceive immediately the residents falls. Some patients use electric-powered wheelchair to move themselves around the building. Very often they require assistance to open doors. In such cases they just need to say the proper command. These patients may also communicate the caregiver by depressing a button on their wearable tag or by issuing another command.

Karin et al. [22] claimed that many assisted living systems are based on a lot of sensors, actuators and multimedia equipment, but the problem of elderly loneliness is often neglected. The authors' project includes the use of audio-visual components that open the home boundaries and allows the interaction with remote relatives and friends. Similarly to the known approaches, the planned system helps everyday problems, such as finding the reading glasses; controlling the heating; recognizing the emergency situations, for instance, person lying on the floor or fallen down the stairs; preventing accidents, e.g. with forgotten turned-on oven. In addition, the system is focused on several complicated social services like playing cards with one another or having common dinner. The authors found that TV sets and large computer monitors are not the ideal solution for monitoring and communication. The whole system should be simple to use since elderly people are not familiar with dedicated input devices like computer mouse, keyboard, etc. Actually, they are a heterogeneous group with different needs for help, capabilities and learning abilities. Therefore, the authors give preference to Linux based computer and projectors with canvas installed at convenient place where people can spend time with their relatives. Homes are equipped with sensors that

measure the state of the inhabitants and support the communication and cooperation between them and their friends. In this way the remote relatives will be able to check whether windows or doors are open, water is flowing, etc.

Holtzinger et al. [16] evaluated the user acceptance of a wrist device, designed to monitor vital signs and to detect situations, such as falls, unconsciousness, etc., and aimed a further study to show the acceptance level of the elderly to the personal monitoring.

Healey et al. [14] presented a prototype wearable monitoring system capable of recording, transmitting and analyzing continuous ECG and accelerometer data. The system also provides an application for recording activities, events and potentially important medical symptoms. The authors conducted experiments using the system for activity monitoring, exercise monitoring and medical screening tests and reported good preliminary results.

Madeira et al. [24] examined the possible increase in the life quality of elderly people by telemedicine that can stabilize the tendency of rising costs due to demographic changes. The proposed system integrates smart objects as wheelchairs and walkers with the corresponding embedded sensors for remote measurement of mechanical and physiological parameters. Thus the elderly will be monitored in various situations: lying in bed or walking with some of the supporting means. An exemplary recording of balistocardiographic signals is shown in the paper illustrating how to obtain information about the heart rate and its variability through appropriately mounted accelerometers.

Some studies [10, 25, 27, 28] are directed to the development of smart home where frail elderly, chronic illness sufferers and people with disabilities may enjoy greater independence and improved quality of life including by reducing the unnecessary hospital admission. Intelligent monitors may keep continuous watch on patients' vital parameters. Technologies that can track the changes in activities and alert the care provider are: smoke detector; flood detector activated by contact with water; temperature sensor; gas detector; bed occupancy sensor; chair occupancy sensor; fall detector; pendants around the neck, on the wrist or clipped to clothing; epilepsy sensor placed underneath the bed sheet, etc.

The publication of Qixin Wang et al. [26] describes the prototype of the so called I-Living architecture for assisted living that includes various embedded devices like sensors, actuators, displays and Bluetooth-enabled medical instruments either operating independently or coordinated under local intelligence node. This unit can be a specialized PC or a black box equipped with one or more wireless interface cards. Independent devices may communicate with the corresponding server over the Internet that provides web-based interfaces to allow caregivers, health care providers and medical experts to monitor the environment and analyze the measured data.

The *Aware Home* project of the Georgia Institute of Technology [12] targets to create a home environment that is aware of its occupants' activities. The services range from enhancing social communication to assisting the users in resuming interrupted activities based on past events recorded by video camera.

De Ipiña et al. [8] reported an approach to address the AAL objectives they called ZAIGUNE research project. The authors aimed to create middleware using OSGi technology – a dynamic module system and service platform for Java programming language that allows remote installation and update of different applications. This technology coordinates sensing and

actuation devices with different protocols. The ZAIGUNE project offers several mechanisms for helping users and administrators. In particular, a simple icon can be depressed by the elderly person to seek help both from his family and from a care centre. As a result of such interaction an automatic phone call is performed to a phone number for transmitting of pre-recorded alert message.

De Florio and Blondia [9] conclude that expanding the traditional approaches to social organization might not be enough for effectively assisting the elderly people. Systems must be radically rethought in order to achieve a truly rational use of the available resources.

Conclusion

The above mentioned projects are only a part of that we collected in the field of AAL (data is available also for COGKNOW, MPOWER, ALADIN, CAALYX, EMERGE, OLDES, SENSATION-AAL, I2HOME, MONAMI, INHOME, EASY-LINE+, ENABLE, PERSONA, SHARE-IT). The analysis of the results obtained and the emerging tendencies shows that the topics discussed are up-to-date and will continue to be significant in the forthcoming years. The different projects are directed to solve the problems of some objective oriented groups (adults with special needs and people with profound restrictions). The applied approaches and implementations are specific that limits the dissemination of the results.

Our opinion is that for some countries with lower Gross Domestic Product, the efforts, for a start, have to be directed to creation of low-cost assistive systems, which can be easily adapted to the need and health status of living alone adults or disabled people. Such flexibility is the precondition for universalizing as far as possible the hardware that would result in quick manufacturing of the product with decreased price. Analogously to the telemetric monitoring systems for high-risk patients, relatively simple AAL systems may perform two basic tasks:

- not to miss to alert life-threatening situations;
- to reduce to minimum the false alerts, which represent the common cause for compromising such type of systems.

Besides the permanently available communication interface between the caregiver and the user, one may point out also the automatic fall detection and signalization, as well as the instantaneous monitoring of photo-plethysmographic signals as very important vital parameters to be continuously observed.

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