Matching technologies of home automation, robotics, assistance, geriatric telecare and telemedicine

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F. Franchimon, M. Brink. Matching technologies of home automation, robotics, assistance, geriatric telecare and telemedicine. Gerontechnology 2009; 8(2):88-93; doi: 10.4017/gt.2009.08.02.007.00 The aging society could have a greater societal impact than the current financial crisis. The percentage of older adults has increased while the size of the health care workforce has remained constant. Home automation, robotics, assistive technology, geriatric telecare and telemedicine can support independence in older adults and diminish the health care burden. Currently, delivering services through these technologies is accomplished mainly through stand-alone systems. Multiple stand-alone systems in one dwelling become a multidisciplinary technological challenge of risks and benefits. Ideally, only those technology mediated services requested at a particular moment should be provided. This calls for a reduction in the barriers between healthcare and technology disciplines and an intelligent network using software agents supporting optimal integration and interoperability to increase the quality of life of older adults and decrease the healthcare burden in our aging society.

Key words: interoperability, intelligent networks, plug-and-play

Buckheit[1] has suggested that the impact of the ageing society could be of greater concern than the current financial crisis. The ratio of persons 65+ years of age to the labour force (15-64 years) will rise from 25% in 2005 to 31% in 2020 and further increase to 52% in 2050[2]. Since the absolute number of registered nurses is expected to remain constant[3], an enormous pressure on the health care sector will result. Most gerontechnologies are developed for functional compensation and assistance to ease the burden on the care sector[4].

In this study we address home automation[5], robotics[6], assistive technology[7], geriatric telecare and telemedicine[8] (*Table 1*). These technologies have long histories of use supporting the aging society by improving the quality of life of older persons through ICT (Information and Communication Technology)[5-8]. More than ten years ago Healy[9] argued that ICT would change health care, even then telematics was found to be cost effective in terms of time, money, quality and accessibility.

Currently, most home automation, robotics, assistive technology, geriatric telecare, and telemedicine systems are stand-alone, having no operational dependencies on other systems. These technologies have individual taxonomies, methods, protocols and standards that may not integrate easily. Nevertheless, there exists a huge conceptual overlap between the intended functionality of apparently similar systems. For example, tracking people with ultra wideband (UWB) sen-

Table 1. *Definitions of different technologies that are able to support older adults*

Technology	Definition	Source
Home automation (smart home, domotics)	A field within building automation, specializing in the specific automation requirements of private homes and in the application of automation techniques for the comfort and security of its residents	40
Robotics	Includes intelligent machines and systems used, for example, in space exploration, human services, or manufacturing	41
Assistive technology	Technology to improve quality of life in case of impairment or disability	42
(Geriatric) telecare & telemedicine	'Medicine practised at a distance'; it encompasses diagnosis, treatment, and medical education	43

sors inside their home to detect wandering could secondarily serve to control entrance and exiting through doorways[10].

Technological integration is desirable to provide higher quality support at a lower cost for the changing needs of the individual elder across time. In this contribution we propose an integrated technological environment to maintain vitality of older adults, and lessen the burden on health care professionals.

Needs and functionalities

The first step to tighter integration is identifying the needs of users to define the functionalities required. Individual needs are studied in the gerontology disciplines (physiology & nutrition, (social) psychology, social demography, and medicine & rehabilitation) and are diverse in nature, ranging from health & self esteem to housing & daily living, mobility & transport, communication & governance and work & leisure[11]. The Functional Independence Measure[12,13], the Barthel and Katz indices for Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL)[14,15], the SF-12[16] and the Loneliness scale[17] are helpful for identifying many needs of older people. Maslow's hierarchy of needs is a useful guide for engineers in the design process[18,19]. These theoretical constructs and instruments applied to the study of the needs of each individual user will yield different outcomes over time as the person ages.

Translation of these needs into the complementary functionalities provided by gerontechnologies constitutes the field of engineering which aims to improve the quality of life[4], through life enrichment & satisfaction, prevention & engagement, compensation & assistance, or care support & care organization[11].

Existing classification systems are helpful in cases of compensation, assistance, substitution or care. Individual capabilities are addressed in the International Classification of Functioning, Disability and Health (ICF)[20] and technical aids are well presented in ISO 9999[21]. However, none of these classification methods capture all of the individual deficit needs defined by Maslow. They represent a first attempt to guide the collaborations of gerontologists and engineers through the use of common taxonomies and lexicons.

Stand-alone

Most technologies are developed to operate as stand-alone systems. This design choice is commonly made in anticipation of adverse impacts of dependencies with other systems. Today multiple stand-alone systems for home automation, robotics, assistive technology, geriatric telecare and telemedicine may be found in a single home environment (*Table 2*). This is cumbersome to the user and is an inefficient use of resources.

Multiple stand alone systems force the user to learn to manage a number of different devices and services requiring mastery of multiple user interfaces: different ways of signalling the user (sound signal, text mes-

Table 2. Examples of typical stand-alone technologies for home automation, robotics, assistive products, geriatric telecare, and telemedicine in relation to their goal and application domain

		Application domain				
		Health Self-esteem	*Housing Daily living*	*Mobility Transport*	*Communication Governance*	*Work Leisure*
Main-goal	*Enrichment Satisfaction*	- Nike+©	- Intelligent thermostat	- Movable steering-wheel[44]	- Assistive social robot[45]	- Wii-fit©
	Prevention Engagement	- Ventilation[46]	- Ventilation[46]	- Low boarding-step busses	- Cellular phone	- Home trainer - Wii-fit©
	Compensation Substitution	- Home robot	- Toilet for disabled person	- Segway© - Wheelchair	- Wireless phone	- Hearing aid
	Care support Care organization	- Telesession with physician	- Entry control	- Public transport for disabled	- Personal alarm - Video phone	- Sporting heart rhythm monitor

sage, graphic user interface), and different control interfaces (buttons and menu structure, touch screen or just one on/off switch). Older people often have problems mastering a multitude of interfaces[22] which may increase feelings of anxiety and even hostility towards new technologies[23].

Since user needs are usually multiple, differ from person to person and change over time, a static system cannot by definition fulfil them. For example, an ICT network capable of hosting most stand-alone applications (*Table 2*) also needs to be extensible to new, not yet invented applications.

Sharing resources

Another disadvantage of multiple stand-alone systems is the limited use of resources offered by other systems. Information and hardware are not shared, yet sharing information leads to better informed decisions[24,25]. For instance, after observing that a dwelling occupant has an irregular heart rhythm, the telemedicine system might issue an order to the home automation system to unlock the door so emergency service personnel may enter the dwelling. This is hard to realize with stand-alone systems which lack integration.

Besides information, systems may also share hardware components (sensors, processing power, etc.) of other systems. This avoids superfluous hardware components and capitalizes on economies of scale. For instance, only one movement detector needs to be installed in an area for both the automatic lighting and the burglar alarm system.

To guarantee reliability, however, redundant components can be included. As an example: systems that need internet connectivity, can also be equipped with a Universal Mobile Telecommunications System connection (UMTS), currently used in mobile phones, to use when the internet connection is down. When the redundant UMTS system is shared by all systems requiring internet services, only a single UMTS device is needed.

The disadvantages of stand-alone systems could be solved by connecting all applications to a centralized host containing all required intelligence, leaving the stand-alone systems devoid of smartness. Although information and hardware are shared, failure of the centralized host means the loss of all functionalities. Thus centralized systems may lack the robustness needed for real life applications.

A system having distributed intelligence, akin to stand-alone systems, but with the ability to share information and hardware components, as in centralized systems, is therefore desirable.

Multidisciplinarity

Integration of technologies implies careful attention to their multidisciplinarity. All technological disciplines have evolved their own vocabularies, methods, protocols and standards. Experience has shown that without a set of well defined standards and protocols, problems of technology integration are to be expected. For example, interoperability of home automation and telemedicine systems has not been successful because of the lack of a standard communication language[26]. The rapid evolution of the ICT disciplines opens a way to diminish the barriers between applications, by designing an intelligent heterogeneous ICT network able to cope with technology differences and hosting distributed intelligent systems supporting the technologies required.

Integration

Kearns & Fozard[27] reported two rapid technological changes in the last decade that make advantageous integration possible: (i) an increase in network speed and bandwidth (ii) the evolution of computational devices as embedded systems in the built environment.

In addition, the 7th Framework R&D Programme of the European Community, includes a thematic activity on ICT & Aging (FP7 ICT-2009.7.1) with a target 'Open Systems Reference Architectures, Standards and ICT Platforms for Ageing Well'[28]. One of the participating projects, OASIS[29], seeks to achieve better integration by providing a platform which is open, modular, holistic, easy to use and standards compliant. In the previous Framework Programme (FP6), this topic was addressed in the Information Society Technology area, and one of the supported research activities in this area was the 'Amigo' project[30], that aimed at integrating technologies by following the Service Orientation Architecture paradigm, in which software developed as services are delivered and consumed on demand. Several research projects in different technologies have used software agents (task-performing software components that are autonomous, not requiring other software components)[31], in home automation[32-34] and in telemedicine[35,36].

Applying this new knowledge to a home environment for 'Aging-in-Place', leads to the notion of an intelligent ICT network. All devices of older stand-alone systems (e.g. sensors and user interfaces) are equipped with intelligent software agents (ISA) that perform tasks autonomously to satisfy user needs by monitoring the status of and controlling the device and attempting to make the appropriate decisions based on artificial intelligence algorithms. As an example, a television equipped with such an agent would optimize the screen settings, check all channels and decides to switch to the DVD-channel when a DVD is inserted in the DVD player. Because the ISAs are connected through a network, they are able to communicate and mediate with each other. By sharing information and issuing each other orders, the multiple agents cooperate as a system and integrate each other's functionalities. In the example of the television, the home automation sensor agents will be aware that all occupants have left the dwelling, so the television can switch itself off.

Distributed intelligence

Multiple software agents in the network result in one form of distributed intelligence. This increases robustness by avoiding the need for an intelligent central host. Functional interdependencies are handled by a Service Orientated Architecture (SOA) as validated in the Amigo project: all functions are defined as services[26]. In this scheme, agents offer one or more services to users or to other agents.

The communication protocol used by the software agents should be, as far as possible, independent of the technological discipline governing the development of the agents' devices, or types of devices supervised by the agents. Furthermore, the networks chosen are heterogeneous and support multiple communication protocols, since a uniform standard or protocol for home automation, robotics, assistive technologies, geriatric telecare and telemedicine does not exist. Software agents so designed constitute the universal interface between different devices, systems, entities and technologies.

To account for temporally changing needs, the agent network supports intelligent plug and play. After connecting a new device to the network, the agent of the device will automatically detect other agents, configure itself and commence its operation, as has been demonstrated by Universal Plug and Play (UPnP)[30,37-39].

Conclusion

Matching technologies of home automation, robotics, assistance, geriatric telecare and telemedicine is required for assuring an optimal quality of life in our aging society. The complexity of combining technologies from different disciplines while taking into account the variety of individual user needs that evolve over time, demands integration with an intelligent ICT network. The ideal network should be based on existing technology: intelligent software agents, fully distributed intelligence, SOA, UPnP, and should support multiple standards and protocols. Development of such a system is currently in the simulation phase to be followed by testing in a housing project[34]. This approach combines functionalities and applications from different technologies to perform more effectively in providing the best environment for aging individuals, while reducing the burden of care.

Acknowledgement

This contribution has been presented in a symposium (Gerontechnology for optimal health in a multidisciplinary context) at the 19th IAGG World Congress of Gerontology and Geriatrics in Paris, July 2009. The authors wish to thank Dr. William Kearns for his fruitful comments on the manuscript.

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