

Telegerontology® and Mobile Robot Companion

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(Abstract) Technological progress and changes in society, together with an increasingly ageing population, especially in developed countries, have demanded solutions to the problems linked to this aging and the increasing number of elderly people. We describe two assistive systems being currently developed and improved; the first one “Telegerontology®” is a gerontological resource that through the Internet, facilitates different functionalities at home or in institutions such as physical and cognitive intervention, and providing support to professionals. The second one “CompanionAble” consists of an integrated system Smart-home and intelligent robot to give support

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to the elderly with mild cognitive impairment and their caregivers. The system, which can move about in the home, incorporates functionalities such as an application of cognitive stimulation, an event agenda and a video-conference system. In conclusion, we consider that though the evolution of new technologies for the support of elderly and/or disabled people has experienced a great advance in the last years, and despite new future system as Telegerontology[®] or CompanionAble, human being support is still necessary for achieving their objectives. This fact is very positive because we ensure the presence of a health professional behind each patient.

[Key words: Ambient Assisted Living, Elderly People, Robotics, Telecare, Telegerontology, Telemedicine]

Introduction

Technological progress and changes in society, together with an increasingly ageing population, especially in developed countries, have demanded solutions to the problems linked to this aging and the increasing number of elderly people. This population, due to the ageing process, is subject to loss of functional ability and the need for care and attention from a third person. The increase in the number of elderly people will thus increase the pressure on the public sector for long-term care. In light of these needs, health care structures and the organization of services will have to evolve new products and services. Information and communication technologies (ICT) try to offer such solutions for both, elderly people and their caregivers (formal and informal).

The possibilities of ICT in the field of support and/or attention to the elderly are huge, especially considering the possibility of offering services to a population who are geographically remote and/or confined to their own home or a care home. Some of those have already been exploited

successfully commercially whereas there are others which are still being developed. There are many of devices addressed to the care of the elderly and/or disabled people in order to help them to live independently at home avoiding any possible risk: from telealarm and telehealth systems allowing the users to contact an attendance centre by phone to real telemedicine services that are able to perform remote surgery, there are a variety of intermediate devices.

Telemedicine has been defined as a care system that uses telecommunications and computer technology to substitute for face-to-face interaction between patients, physicians and other healthcare professionals in various combinations (Bashur, 1995). These devices are also being used to support family caregivers and reduce the burden linked to the task of care. Therefore, those are supportive systems targeted at different users, elderly people, formal and/or informal caregivers (family, friends, professionals, etc.).

In this article, we are going to introduce two of the assistive systems the Gerontology Research Group at the University of A Coruña in Spain is currently working on; the first one Telegerontology® is a gerontological resource that through the Internet, facilitates different functionalities at home or in institutions such as physical and cognitive intervention, and provides support to professionals. The second one CompanionAble consists of an integrated system Smart-home and intelligent robot to give support to the elderly with mild cognitive impairment and their caregivers. The system, which can move about in the home, incorporates functionalities such as an application of cognitive stimulation, an event agenda, and a videoconference system. This system is developed through collaborative research in a European project led by the University of Reading in United Kingdom.

Telegerontology[®]

Concept and Functionalities

The applications of ICT in the field of caring for elderly people have promoted the presence of new systems addressed to this target population. It is important to point out that those new products and services should cover three long-term objectives: accessibility, quality, and viability. Accessibility implies that ICT must be affordable for elderly people with lower incomes; quality means providing high-quality health care that is to achieve the governmental standard of an optimum balance between the health benefits and the cost of medication and treatment; and finally, viability implies that a certain level of financing is required to ensure the availability of high-quality health care that is accessible to the target population. Taking accessibility (Berners-Lee & Fischetti, 1999) and usability (Nielsen, 1993) standards as a starting point, Telegerontology[®] is a new gerontological resource integrating different functionalities, and is developed for the needs of the elderly.

Following, we will describe this resource and its functionalities in detail. When the user accesses the main menu, they will see a row of icons, displayed at the top of the screen, which relate to the functioning of the system (see Figure 1). These relate to connecting to the Internet, to the control centre, an alarm and the level of the battery charge or connection to the power supply; on the lower part of the screen there are six links related to the functions. The first one "Contents" includes different presentations, giving the user interesting information presented in a simple way, regarding socio-sanitary regulations, health guidelines and disease prevention, as well as presentations about risk situations such as falls.

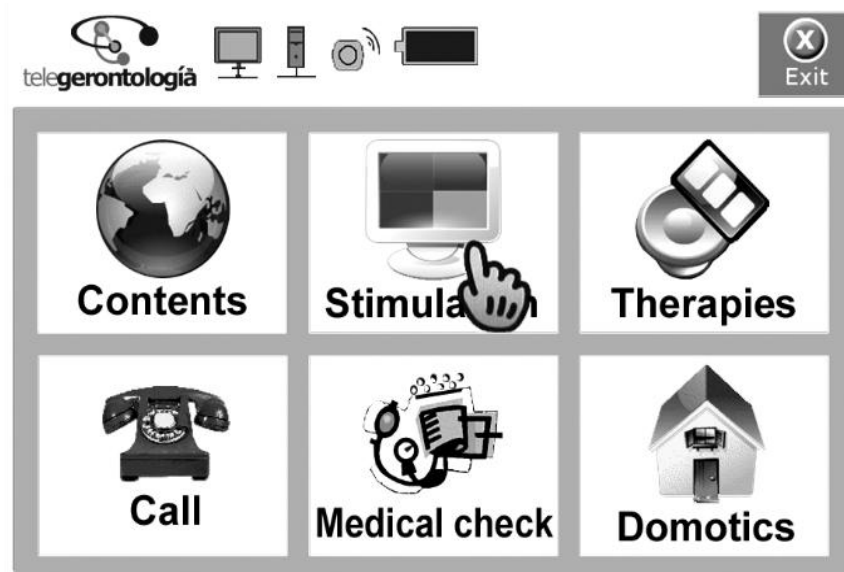


Figure 1. Main menu of Telecognitio®system

The second function links to the “cognitive stimulation” application Telecognitio®. Telecognitio® has been developed from analyzing current products on the market and avoiding their faults. When the user accesses the icon “Therapies,” a second menu opens showing a list of videos including educational content developed by professionals from the gerontological and geriatric field. Those videos offer exercises or games to the elderly with the aim of promoting physical or cognitive training. Videos can be displayed at the user’s demand every time, and even some live videos with professional interaction are included. The next icon, “Call,” opens a window showing the professionals available at that moment. Clicking onto the link of each professional is enough to contact him/her and initiate a video-conference.

Moreover, a videoconference will start every time the user presses on the telealarm system. The difference between both procedures is the priority given to the call. An alarm call activates an application showing the medical history of the patient and at the same time the user explains his/her problem, so that the professional has all relevant medical information. The next service, "Medical checkup," shows a menu with icons to carry on multiple remote biomedical tests. Nowadays, we are implementing the register of blood pressure, body temperature, pulse and oxygen saturation levels. Shortly, other tests will be added: glycaemia control, electrocardiography or spirometry. Lastly, the sixth icon "Domotics," includes a menu showing various home devices controlled by Telegerontology[®], such as blinds and lights.

As a complement to the system, the user has a telealarm facility based on a wireless device used as a bracelet, necklace or clip belt. When the device is activated, and the user is within the receptor's range, the signal is received and a videoconference starts between the domicile and the alarm centre to check the status of the elderly person and to call for help if necessary. In that case the user is outside, the alarm device will send a signal directly to the alarm centre indicating his or her location. These are the functionalities included in Telegerontology[®] at present.

If we go into the detail of some of these functionalities and more specifically, with regard to the application of cognitive stimulation (Telecognitio[®]), this has the option to intervene among the seven brain areas with possibility of intervention. This means that the program includes specific activities according to that area being stimulated: orientation, perception, attention, memory, language, calculation, and praxis. Prior to intervention and periodically, Telecognitio[®] incorporates an instrument of cognitive assessment, making it possible to assess the cognitive level of the user, his/her

progress or set-backs and even more important, it makes it possible to adapt each session's activities to the user's cognitive level. In accordance with that level, users are classified into four groups: Level I - moderate cognitive impairment, and including also those patients with advanced cognitive impairment but able to participate in stimulation therapies; Level II - mild-moderate cognitive impairment, including patients with cognitive impairment but not too marked; Level III - mild cognitive impairment; Level IV - subjective memory losses or age-associated memory impairment, including patients without cognitive impairment but with benign oversights.

The initial diagnostic assessment in Telecognitio[®] occurs the first time a patient participates in the stimulation program, being assessed from 0 (worst) to 10 (best), and then, once a month or each 12 sessions for monitoring the impairment progress. This assessment starts from the highest impairment level and it is resourceful in its application until it achieves a firm diagnosis. With this information the cognitive capability level of the carerecipient is obtained, by taking into consideration as a percentage of 80% the score obtained during the latest assessment of the patient and, as 20%, the mean score of latest assessments during the last month. Once the starting point is calculated, specific stimulation activities from each cognitive area to the corresponding level are established.

There are other highlighted characteristics of Telecognitio[®], such as the presentation of activities through visual and auditory channels, the presence of reinforcements always in a positive way, the restriction of a maximum number of answer attempts, time restrictions according to the degree of difficulties in the activity; and the presence of mediation screens to mediate between the current attention focus and the invocation of a help facility from the program.

Continuing with the monitoring of the biomedical parameters of the elderly, after selecting the icon "Medical checkup," the system

requires user authentication via login and password. Following this, icons referring to different possible choices will appear on the screen: to measure blood pressure, pulse, the user's temperature or the oxygen saturation level in peripheral blood. If we take the blood pressure determination as an example, the user must check the connection between the sphygmomanometer and the computer (set-box) by USB connection. Next, he/she must select the corresponding icon and a menu will appear, giving information about the positioning of the arm and the bracelet on the wrist. After pressing the "To continue" button, the user will be guided in the procedure to measure blood pressure, simply by pressing the "start" button.

The cuff is inflated and deflated slowly and the values of systolic and diastolic pressure will appear on the screen, together with the pulse frequency. Next, a new menu explains how to send the medical information to the control centre. After being sent and according to the algorithm previously created, the user will be informed about the loading end and will receive some advice based on the obtained scores to reinforce healthy habits. If during the registration procedure and the sending of biomedical data an error occurs, a new menu will inform the user and/or his or her caregiver(s) about the existing problem and the way to solve it. Once the data is transmitted, it will be managed from the control centre and all registered data will be stored in the medical history of the user. This procedure is similar to the other measurements of biomedical parameters, changing only those features referred to the measuring device. In sum, the idea behind the full Telegerontology[®] system is to improve quality of life, autonomy, and dependency thanks to the application of new technologies in the care and support of elderly people and/or their caregivers.

Structure

Telegerontology[®] tries to put the users and/or their caregivers (at domiciles, institutions, health centers, etc.) in touch with the professionals (control centre or other physical location) remotely. It is very important for the professionals to have access to the information included in the medical history of the patient, which also includes monitoring results such as cognitive level, biomedical parameters, and falls. All information is included in a server placed at the attendance centre or through “housing” in the service supplier.

Besides this, we must also facilitate communication among stake-holders. The Internet is used as a way to communicate between the control centre and the end-users due to its wide distribution and its increasingly affordable cost. For this, different devices must be installed at the elderly person’s domicile: emergency device, camera (to supervise the user condition and manage video-conferences), devices for monitoring vital signs and a computer integrating all these services and using an access to a network of broad band (ADSL, HDLC, etc.).

This original structure will grow and be modified quickly in number and type of device as other more adapted devices are focused on the patient’s needs. For this, the software integrating the functionality in the computer is modular and, as far as possible, independent. The system is divided into services where each service is directly connected (pluggable) into the main server. The control centre, together with the call-centre for attending to the users’ needs are installed in the communication centre that includes the servers; including the rooms for recording and broadcasting therapies and some offices for the support personnel. The call-centre focused on alarm call attention could be located in another place if necessary.

Moreover, the system could integrate attention mobile units for solving different situations at the remote centre, as in the case of the installation of needed equipment. Figure 2 includes a graphic representation of the architecture of Telegerontology[®]. This structure will facilitate the access of those functions adapted to the elderly and/or their caregivers.

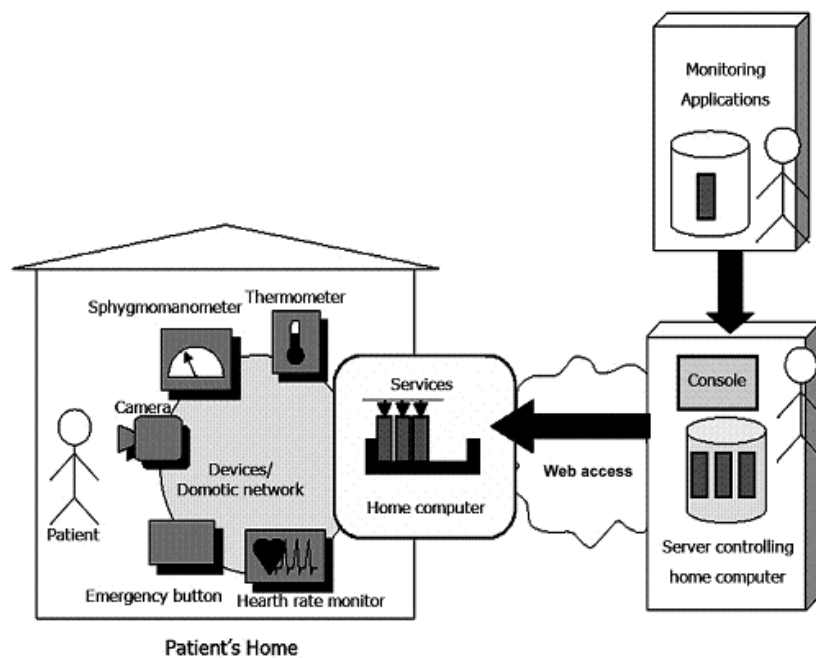


Figure 2. Representation of the architecture of Telegerontology[®] system

Mobile Robot Companion

Target Group

As the average life expectancy increases, more diseases arise in conjunction with the ageing population, and mild cognitive impairment (MCI) is a disorder linked to the older population. Different studies with elderly European samples (Graciani et al., 2006; Ritchie, Artero, & Touchon, 2001) showed its rates of prevalence between 21 and 27%. MCI is a clinical label that includes elderly subjects with short-term or long-term memory impairment and with no significant daily functional disability. Research suggests that this population is at high risk for developing dementia with 10-15% per year succumbing to Alzheimer's dementia (AD) compared to 1-2% of unimpaired older adults (Petersen et al., 1999).

Therefore, it is relevant to keep the elderly cognitively stimulated and the innovative/assistive technologies play an important role in increasing such cognitive functioning. People with MCI retain a large range of cognitive capacities, which make them an ideal target for cognitive training. Also, it is likely that brain plasticity is distinctly possible in the elderly (Kopytova, Mednikova, & Popova, 2004). Decades of memory research clearly demonstrate that elderly adults have the cognitive plasticity to benefit from memory training (Ball et al., 1988; Verhaeghen, Marcoen, & Goossens, 1992). To incorporate new healthcare technologies for improving quality of life and elderly care, increasing their autonomy, can contribute significantly to support the elderly and their caregivers (formal or informal) and is to become a major priority of ICT applied to gerontological research.

Functionalities

Revolutions in longevity and ICT have not evolved together and many computer applications have overlooked the special needs of the elderly. As a result, elderly adults are practically excluded from the current information society. Accordingly the EU project “Integrated Cognitive Assistive & Domestic Companion Robotic Systems for Ability & Security” (CompanionAble - <http://www.companionable.net>), is developing a service for helping the elderly to live at home (semi)-independently for as long as possible. It involves 18 organizations from 7 European countries, and is supported by the European Commission under the strategic objective “ICT and Ageing” of the Seventh Framework Programme. The project aims to provide a new AAL solution for supporting a person with mild cognitive impairment and/or his or her caregiver via new technologies and functionalities, by means of a helping robot in a smart home (Figure 3). The system includes a mobile human-like robot in the house, which recognizes the person’s needs and potential dangerous situations and automatically asks for external help if necessary and desired. Additionally the house itself is a kind of intelligent entity, which means that it will recognize events such as when a person falls and will call for help if this is desired.

The system will provide different functionalities such as mobile video conference, monitoring of all rooms, intelligent day-time management, content generation for cognitive stimulation and training, reminder function for medication taking and analysis of acquired data regarding the health status of the care-recipient and, social communication with relatives or caregivers. It is essential that the design of any ICT-enabled caring environment is based on previous studies of the target population, the elderly in our case (Millán-Calenti, 2006). Nowadays, we must highlight that the totality

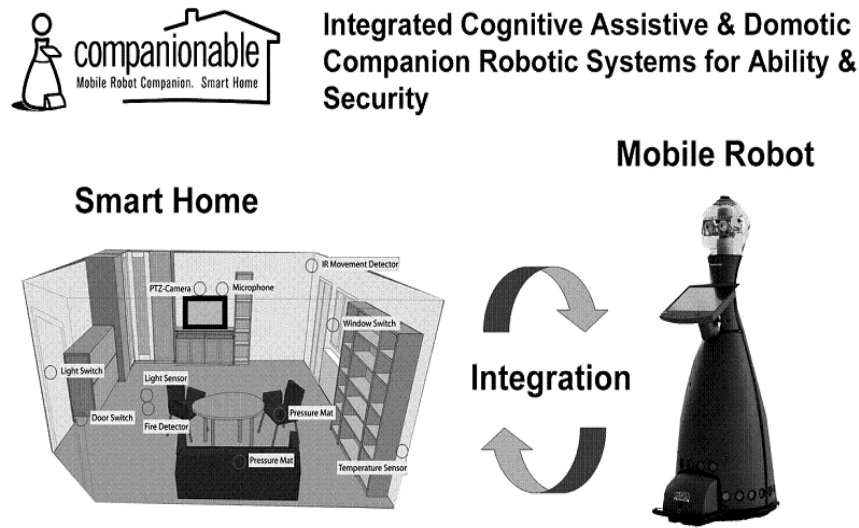


Figure 3. Integrated Cognitive Assistive & Domotic Companion Robotic Systems for Ability & Security

of functionalities the system will offer its target stake- holders are based on a systematic analysis of the real target user's most-deeply-valued needs, ensuring that the offered technology is adapted to user's needs. It is necessary to balance the accommodation, of the users' needs by the system at the same time as providing sufficient opportunity for the user's self-actualization by exercising their self-management and autonomy (referred to as "Reachability" in C-Assure; Badii, 2004). We fully expect that ICT and advanced digital technologies will contribute significantly to maintaining, indeed improving, the quality of life in the context of the dynamics of our personal; and cognitive abilities with ageing (Badii, 2009). The technology for AAL needs to be user-intuitive, also remains as

user-intimate yet as un-obtrusive and invisible as possible, through seamlessly adapting to the user's changing levels of ability and comfort, which will change both from person to person and as individual's abilities change with age (Badii, 2000).

However, there are some critical aspects and serious challenges concerning the development of ambient intelligence in the field of housing. Home is a sanctuary, so technology and technological devices integrated to the house should not dominate the overall function of housing. The technology should enhance the quality of life of residents, not only by facilitating their daily activities but also supporting their socialization. Another major challenge for ambient intelligence is how to make technology learn about the people and their identity (habits, preferences, behavioral patterns, etc.) and how to apply such knowledge in varying contexts. Such situational awareness should be promoted simultaneously securing a sufficient degree of privacy and prevention against misuse (Friedewald et al., 2005) and this will be taken into account on the CompanionAble research.

Discussion

Since 1999, when Dr. Khalid Mahmud founded American Tele-care and tested a device for measuring blood pressure into an aluminium box connected to a videophone, the evolution of social and medical services both at distance and through a robot has been huge. These services are not yet able to substitute for the human being and probably, we should take the Galindo, Gonzalez, and Fernández-Madrigal's (2006) interpretation into account believing that human support should facilitate interaction with the machines, proposing the concept human-robot-interaction (HRI). Ambient

Intelligence (AmI: Aarts, Harwig, & Schuurmans, 2001) is considered the enabling technology for a new generation of systems which provide their services in a flexible, transparent and anticipative manner requiring minimal skills for HRI. "Ambient Assisted Living" (AAL) as a specific, user-oriented type of "Ambient Intelligence" may greatly help in this situation. There is a huge potential in the area of living assistance and AAL is currently one of the important research and development areas where accessibility, usability, and learning play a major role and where future interfaces are an important concern for applied engineering (Kleinberger et al., 2007). AAL helps people to live longer and independently in their preferred environment. Due to the high potential of emergencies, a sound emergency assistance is required; for instance, assisting elderly people with comprehensive ambient assisted living solutions sets high demands on the overall system quality, and consequently software and system engineering user acceptance and support by various user-interfaces is an absolute necessity.

AAL can help those with special needs and the growing group of elderly to live longer in the place they like most, while ensuring a high quality of life, autonomy, and security. This ICT support includes facilities for environmental control, information access, communication, monitoring, medical follow-up, physical exercises, built over diverse technologies and using different ways of operation. Therefore, AAL solutions enable the delivery of integrated functionalities at home. Several systemic reviews (Barlow, Singh, Bayer, & Curry, 2007; Botsis & Hartvigsen, 2008) have verified the importance of remote services applied to elderly people, above all they have referred to the chronic pathologies, with high user satisfaction regarding time saving if compared with the time spent in visiting the doctor. Miyauchi et al. (2003) propose a system to remotely control the patient's position and movements when he/she walks, runs. There are a lot of developed

experiences and possibilities of telemedicine giving us the option to send almost every kind of information through the Internet to be assessed or interpreted by other professionals or even to establish diagnosis or intervene without contacting the patient.

Pervasive home monitoring is set to play an important role in maintaining the independence and improving the quality of life for elderly people at a lower cost (Rajasekaran, Radhakrishnan, & Subbaraj, 2009). In the context of an ageing population, the aim is to develop tools increasing the autonomy and supporting the independent living of elderly people to enable them to play a more important role in society. Due to the high costs of institutional living (Friedewald et al., 2005), there is an important incentive for the social security and pension systems to encourage such tools if the evidence of prolonged independent living is provided. These tools should include not only means to monitor safety, health status, location and needs of people, but also to compensate possible cognitive or functional impairments (e.g., remote control of different electronics appliances and doors), add security (fire and burglary alarms forwarded to caregiver, automatic protection mechanisms for electronic appliances such as the iron and oven), and provide improved means of communication.

Cognitive intervention is another approach to support people with MCI in their memory function and can be presented using video conference, computer-based, or internet-based systems. Among those technological tools to compensate cognitive impairment, we must point out the large advance in the field of applications of cognitive training reported, such as: Smartbrain (<http://www.smartbrain.net>) that does not assess the results of the interaction user-application; Cogniplus (<http://www.schuhfried.at>) that needs a specific board in order to work; or Cognifit Personal Coach (<http://www.cognifit.com>) that focuses on cognitive ability training but is not adapted for people

with impairment.

Another point to consider is the fact that the population is ageing, and thus, there will be less people to take care of this increasing number of elderly people. Consequently, research is focused on developing new supportive technologies facilitated by robotics and automation. Instead of moving to care institutions, it is more desirable and often economically viable to live at home as long as possible. Therefore, the present research is concentrated on home automation (Smart homes or intelligent houses) and home robots. Smart Home Technologies mean systems that have sensors and devices for monitoring the users, communicating with others (e.g. video-conferences with their family or medical doctors) and intelligently supporting them in their daily activities (e.g., to take medication, to detect alarm situations, to monitor their functional/cognitive capability). New mobile robotic devices could complement the functionalities offered by smart homes. Dynamic and mobile elements are being introduced to perform activities that require movement, dexterous manipulation or advanced sensing and reasoning. We must always consider that these supportive tools are focused on designing human-friendly and effective human-machine interaction systems for the human being and intelligent homes/robots to coexist and collaborate for improving the quality of life of elderly and improving their independence, autonomy and safety.

Overall, elderly participants and their caregivers respond positively to initiatives such as remote monitoring for older people who live at home (Magnusson, Hanson, & Nolan, 2005). In contrast, participating nurses express concerns that technology may replace direct human contact and obviate the need for professional staff (Whitten et al., 2003). Such attitudes may change as professionals become more accustomed to using technology in the workplace (Danskey & Bowles, 2002). In conclusion, though the evolution of

new technologies for the support of elderly and/or disabled people has experienced a great advance in the last years and despite new future system as Telegerontology[®] or CompanionAble[®], human being support is still necessary for achieving their objectives. This fact is very positive because we ensure the presence of a health professional behind each patient.

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