e-Tools for the disabled and for the new generation of senior citizens. A Position paper

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Abstract

In this paper we present our exploratory ideas about the integration of agent technology with other technologies to build specific *e*-tools for the disabled and for the new generation of senior citizens. In particular, we like to explore the benefits of the concept of *situated intelligence* to build intelligent artifacts that will enhance the autonomy of the target group during their daily life.

1 INTRODUCTION

Nowadays it is clear the growing importance of the role that Artificial Intelligence and Knowledge-Based Systems (KBS) are playing in medicine for supporting medical practitioners in making decisions under uncertainty (see [11]). Also in those medical scenarios, where many individuals are involved in a decision-making process or when their decision and actions have to be coordinated, the agent-based technology is getting an increasing role first as modelling the processes (see [8]),[17] and secondly to model the decision making over those processes (see [10]). Most of this work has its roots on the seminal ideas of G.A. Aga [4].

Most of the actual agent-based technologies in medicine could be classified, following [20], as:

- Patient centered information management
- Cooperative patient management
- Patient monitoring and diagnosis
- Remote care delivery

but all those applications are centered in the information dimension of the health care management.

This paper is about envisioning the future use of technologies (as for example *e*-Tools) in which agents and networks will be integrated into everyday environment, rendering access to a multitude of services and applications through easy-to-use interfaces, specially designed for the disabled and the senior citizens.

We are clearly thinking in applications that can be circumscribed to well-know quasi-structured domains (ie. places with predefined components such as a house, a hospital floor, etc) assuming that they are stable, that there exist enough information about them and that the environment somehow is able to interact with a computational system (for instance, by providing information to the system). Recent advances in embedded computing and wireless communication make it possible to think in putting *intelligence* in every appliance, into the structure of hospitals, homes and, in the long term, even on every street corner (see [12]).

Specifically, the long term objectives of our research are:

- To develop the medical and social understanding necessary to apply Heterogeneous Embedded Intelligence technology to problems faced by the disabled and senior citizens population.
- To develop assistive technology for disable and senior citizens.
- To investigate mechanisms by which physical and software agents effectively and securely coordinate sensing, cognition, reasoning, and actuation in well-known environments to support the target population.
- To investigate mechanisms to build flexible interfaces to support the interaction of people with different capabilities and needs.
- To disseminate information and promote the exchange of ideas and create awareness among relevant actors.

The use and creation of new technologies for the disabled is crucial as for this group of people it is not merely a matter of doing the same things more quickly or in a simpler way with the aid of an *e*-tool. For them it is a matter of being able to perform those tasks independently and maybe to learn to perform new tasks in order to enhance their own autonomy.

1.1 Organization

The organization of this paper is as follows. In §2 we address the possible uses of assistive technologies in building services for the senior citizens and give our own proposals for this field. In §2.1 we present some of the technologies to be used, and then in §2.2 we describe the wish list of problems that we are willing to solve. In §2.3 we will discuss the interaction problem of senior and disabled people with such technological devices.

Afterwards, in §3 and §4 we will introduce some futuristic but feasible (and very appealing) applications of assistive technologies, presented from the technical and the social and healthcare perspectives.

In §5 we address the issues of safety and soundness of the integrations of the various technologies in a single platform.

And, finally, in §6, we make some reflections about the future of this technology .

2 ASSISTIVE TECHNOLOGIES AND THE SENIOR CITIZENS

The senior citizens represent a fast growing proportion of the population, at least in the developed countries [6]. They are a heterogeneous group comprising a wide spectrum of function. This ranges from intact robust individuals to those with mild cognitive impairment and/or other disabilities, and to those with moderate to severe limitations. The latter group includes those with Alzheimers disease (AD) and other dementias, physical and other neurological diseases, who require medical assistance and/or institutional care [13].

While Mild Cognitive Impairment refers to the clinical condition between normal aging and AD in which persons experience memory loss to a greater extent than one would expect for age [19], an outstanding example of highly invalidating disease is represented by Alzheimer's disease, the principal cause of dementia in the elderly, affecting about 15 million people worldwide. The earliest symptom is usually an insidious impairment of memory. As the disease progresses, there is increasing impairment of language and other cognitive functions. Problems occur with naming and word-finding, and later with verbal and written comprehension and expression. Visuo-spatial, analytic and abstract reasoning abilities, judgment, and insight become affected. Behavioral changes may include delusions, hallucinations, irritability, agitation, verbal or physical aggression, wandering, and disinhibition. Ultimately, there is loss of self-hygiene, eating, dressing, and ambulatory abilities, and incontinence and motor dysfunction. Last stages of the disease use to lead to an institutionalization in some kind of facility specialized to treat such cases. But this solution not only has a high cost (institutionalization accounts for more than 66% of the costs associed to people with severe dementia), but also is harmful for the patient, that is placed in a unknown envoronment with unknown people.

Assistive technology devices can be very useful to provide supportive services for individuals who require assistance with the tasks of daily living. Such supportive services can also aid informal carers (relatives, friends) to significantly lengthen the time spent by demented individuals in their own home postponing the requirement for institutionalization, to propose substitutes for nursing homes (i.e. Assisted Care Facilities).

Disability makes everyday life very complicated and the informal family support is usually not continuous. The use of technological aid to solve mobility and communication problems inside the patient's house may help to reduce his/her dependency (even from the psychological point-of-view) specially regarding the activity of daily life and improving his/her quality of life.

2.1 Integrating tecnologies to create intelligent assistive devices

There are several technologies that are useful to provide supportive services for physical or mental-disabled people.

2.1.1 Autonomous Agents

Autonomous intelligent agents are capable of understanding their environment and of independently determining and reasoning how to use their own resources in order to reach a desired goal [22] [21]. Such agents can be either physical (a robot) or software components.

Robotics is the field that works with physical intelligent agents. A typical example is a robot which can navigate freely in an unknown, constrained environment. The navigation is one of the main problems in the field and it is solved by several approaches (indoor navigation, outdoor navigation, navigation with maps, reactive navigation) usually assisted by a variety of devices (sonar, ultrasonic and infrared sensors, pressure switches, wheel encoders or even vision systems capable of tracking landmarks). Although there are a lot of efforts in this direction, few of them have been focused on disabled or elderly people [16].

Software intelligent agents are entities that interact with a *virtual* environment, getting information and exchanging it with other agents. Their reasoning capabilities allow them to do complex tasks such as allocate resources, coordinate the action of heterogeneous systems or the integration of information from different sources.

Until now the applications of autonomous agents to senior citizens or elderly people have been directed towards its integration in society via the use of virtual communities, trying to make the Internet technology accessible to them (ie [5] [2] , [6]). These efforts are in line with the Promoting an Information Society for Everyone (PROMISE) EU initiative.

The use of this agent-based technology could be easily conceived to help solving other problems that at first look are very small and easy but that could help to enhance the quality of life of some people. Consider for example the following situation where someone is able to *Remember what but not where*[1] it is located. In a restricted environment as a house or a hospital a software agent may help to trace the location of the desired object by keeping track of the *usual* places where this object should be or the last time it has been used and/or placed. This may require a shared memory between the intelligent agent and the environment, in a way that allows the agent to use some pointers in the environment to *remember* how things were the last time without having a complete memory of the whole scenario. For such tasks, episodic reasoning techniques such as Case-Based Reasoning can be used to remember past usual situations (*episodes, cases*).

2.1.2 Wireless devices

Wireless technologies have created a revolution not only in technology achievement but in social behaviours. Such technologies are daily used to control machines (remote

[1] A related neuropsychological study has been carried out in [7]

controls), to bring communication to any place (mobile phones, beepers) or to provide services at any location (wireless network connections). The evolution in the communication channels (to send and receive the maximum information with the minimum bandwidth use) has also came along with the evolution in computational power inside small devices (PDA's, laptops, last-generation mobile phones).

All these technologies allow the creation of lots of applications and services accessible through small, portable devices, easily carried by people from one place to another, and are the basis for some of the solutions proposed in the following sections.

2.2 Wishing upon a star

The kind of services that we are aiming should be capable of solving the following problems:

- *Monitoring problems*: the creation of devices that can track several signals from sensors placed in the patient and autonomously decide, with a sound reasoning method, if the patient is in a safe condition or there is something abnormal that recommends to call for assistance (an alarm in the case of a Care Facility, an automatic phone call with an syntetic voice in the case of the patient's home).

- *Mobility problems*: The creation of devices (power wheelchairs) that are easilly driven by people with mental and physical disfunctions, and that are capable of autonomously taking decissions about *where* and *how* to go with the limited, even noisy inputs from the user.

- *Cognitive problems*: the creation of devices that can assist the patient to recover from small memory loss, such as where do they placed some item (like the *Remember what but not where* example menctioned before). This is one of the most thrilling problems to be solved, as it requires a combination of technologies (eg. a set of software agents monitoring the user actions and linked with sensors and positioning systems installed in the room, all them interacting through wireless communications).

The use of this kind of tools may ease the healthcare and social interaction of a senior citizen person alone. And may delay their institutionalization by prolonging the period of relative independence of individuals.

2.3 The interaction of disabled people with technology

In the analysis, design and final creation of disabled-oriented devices, it is mandatory to keep in mind the interface problem, either because of a severe mental or mobility disfunction or the usual complicated relationship between older people and new technologies.

The extreme difficulty with which persons with severe disabilities have been taught to maneuver a power wheelchair is an example: 9 to 10% of patients who receive power wheelchair training find it extremely difficult or impossible to use the wheelchair for activities of daily living; 40%. of patients reported difficult or impossible steering and maneuvering tasks; 85% of clinicians reported that a number of patients lack the requisite motor skills, strength, or visual acuity. Nearly half of patients unable to control a power wheelchair by conventional methods would benefit from an automated navigation system. These results indicate a need, not for more innovation in steering interfaces, but for entirely new technologies for supervised autonomous navigation [9].

Our main target is to address the needs of the future generation of senior citizens. It is of our believe that this new generation will be technological savvy [2] and because of this fact will be more demanding. This represents in itself a challenge and an opportunity to further develop new AI technologies and tools and to integrate them assuming that the new future will bring a real Ambient Intelligence that will incorporates properties of distributed interactivity (ie, multiple interactive devices, remote interaction capabilities), ubiquitous computing, and nomadic or mobile computing (ie, location awareness as explained in §4).

3 INTELLIGENT ASSISTIVE DEVICES FOR PATIENT MONITORING

One of the most promising uses of the current technology is the creation of intelligent monitoring systems. Such systems track several body signals and have the reasoning capabilities to decide whether the patient is in a normal or acceptable state or if it is entering into a *danger zone*, even building a diagnosis of the possible causes.

With such devices, residential care facilities for elderly people and disabled persons can be provided with intelligent beds equiped with embedded instruments for acquiring not only vital parameters (blood pressure, glicaemia, pO2) but even with sensors to evaluate pressure at the body-bed interface to prevent pressure-ulcers.

A mobile version of the same technology consists on the creation of a portable device to do the tracking in persons that can move within an area. Such systems could track body signals and trigger alarms when a danger situation has been detected, even sending an automatic call to the caregiver by the use of automatic phone dialers and voice sinthesizers. Another use of such portable devices, wirelessly interacting with devices attached to the room walls, is to monitor the patient movement inside the room, and identify behaviours like wandering as a symptom of dementia, or even detecting equilibrium loss to prevent falls.

4 AN INTELLIGENT WHEELCHAIR

The scenario presented in this section applies almost all the solutions presented in previous sections and is based on a daily problem. Many disabled people[3] of all ages base

[2]A promising example that supports this claim is Japan, where nowadays even the elder people in the countryside areas have adapted to technologies such as the last wave of mobile phones, attracted by the appealing services that are provided by the phone companies through their wireless network.

[3]In 1997, there were over 1.4 million wheelchair users of which 75% used manual versions. The remaining 25% used power wheelchairs. Power wheelchairs are used predominantly by people with both lower and upper extremity impairments resulting from cerebral palsy, high-level spinal cord injury, or muscular

their mobility in the use of a wheelchair and some times it is an power wheelchair. Usually those are driven using a mouse or joystick that allows the chair to navigate. However some disabled people experience considerable difficulties when driving a power wheel chair. Common manoeuvres are not at all easy (ie. going out from a room). When the steering commands are not sufficiently accurate (due to spasticity, paresis or tremor in the upper limbs), a collision can result. And there is a group of target users that is unable to even use their hands. Our proposal is to install on top of the hardware of a electric-powered chair an intelligent autonomous agent with a flexible interface that gives to the users, depending on their individual capabilities, more or less assistance in the navigation. Most of the times the navigation will be assumed by the agent controller. The Tin Man series of robotic wheelchairs [15] are on the origin of many of these ideas. Similar ideas have been funded by the National Institute on Disability and Rehabilitation Research [3]. Yanco elaborated a complete survey of this kind of assistive robotic wheelchairs [23].

Among the ideal characteristics the flexible interface we should include:

- A voice interface,
- A touch pad interface, and
- A shared memory system

this interface should be able to adapt itself to the different user abilities to allow her to control the chair, navigating as smoothly and safely as possible (see §5). For example, the agent controller should be able to react to orders like *Stop!*, *Watch out!* or *No* when it is performing a given plan.

The main task of this interface is to interpret user's commands that could be noisy, imprecise and/or incomplete and transform them in *plausible* orders and plans (§4.1). Most of the times the user would be able only to say *what* is she willing to do, *where* is she willing to go (through a voice interpreter or a touchpad), leaving to the agent controller to figure out *how* to achieve it. These orders have to be integrated in the environment (by the creation of a shared memory as mentioned in previous sections) and follow the user's preferences. This implies that the agent supporting the interface should have knowledge about the current status of the world. In [16] different approaches to interfaces are presented.

Other existing approaches to create interfaces with an electric wheelchair are exploring the use of computing the face expression of a person to guide the chair and in this way take advantage of the user's non-verbal behaviors [18].

To build the appropriate software and hardware support for such autonomy and also to provide healthcare management (embedded monitoring and diagnosis functionalities), we propose the integration of various technologies and AI paradigms as: Agent-technology, Situated intelligence, Heterogeneous Embedded Intelligence, Machine Learning, Robotics, etc. This integration should provide the agents with a set of strategies entailing him knowing *what* to extract, *where* to get it, and *how* to get it. For example, the system should be able to communicate with other agents (some of

dystrophy.

them placed in the environment) and get *relevant* information and be able to decide whether or not that piece of information is useful and should be incorporated in its own knowledge base or not.

4.1 The yellow brick road

Although we are thinking of a controlled situation and well-known environment, structural elements like corridors, rooms, or halls may differ. Corridors in different places in the same building can have a various width, length and illumination sources. The number of rooms and their shapes depend not only on floor but also on the usage of those rooms, etc. The indoor and/or outdoor environment have to be considered differently. Depending on the user, cognitive tasks such as positioning or obstacle avoidance should be delegated to the intelligent agent.

The navigation problem is to build a plan from the actual position to the destination (target). This could be done by using solutions from the Robotics area such as following a map or keeping track of the landmarks or signposts available in the environment (the building) and use them to locate the destination site. Usually the landmarks are passive and it is the mobile entity the one that should recognize them and use them for positioning purposes. But an alternative that we propose here is to use active landmarks, that is, small wireless machines installed in some strategic places of an area to transmit local information to the mobile entity. Similar initiatives and ideas could be found in the design of intelligent buildings for the disabled and elderly people (see for example [1]) or the last generation of road traffic support systems.

Plans to achieve particular goals in this environment need also to be devised (may be off-line using, for instance, a machine learning algorithm as `CANDID` [14]) and whilst these plans are being executed, they need to be continuously monitored. Relevant information extracted from the monitoring of the chair movements could be used to adapt or to refine the plans. These original plans are in some way the set of abilities that the system should exhibit. A first ability that this kind of artifacts have to exhibit is an effective obstacle-detection and avoidance (*reactive navigation*) that will ensure a high level of occupant safety (see 5). And they have to be able to report to their human supervisor and ask for help when encountering problems they cannot handle.

Another AI techniques can be very useful in planning. For instance, Case-based reasoning could be used to adapt or re-use past solutions to face new problems (like, for instance, the set of movements used to cross a narrow door when faced with another one).

5 SAFE AND SOUND

As mentioned above one of the most relevant properties of the domain of application is restricted to a *situated environment* quasi-structured where *small* changes may appear but agents should expect that the most important landmarks will remain stable for long periods. This does not exclude that the domain remains dynamic and therefore *unexpected* changes may arise so the system needs to solve these unforeseen situations.

This kind of systems need to exhibit an intelligent goal-oriented behavior and yet still be responsive to changes in their circumstances.

But as observed by Fox & Das [10], the use of heuristics of rules of thumb to solve problems seems unlikely to inspire confidence. In this domain the safety of users imposes bigger restrictions and the systems must be extensively tested –may be off-line– to assure effectiveness and performance.

Software Agents could be used here to perform an active safety management layer by the introduction of *guardian agents*, as in [10], that in a proactive way look for possible hazards and anticipate an answer or send an alert signal to the manager. For example, an intelligent wheelchair must never obey an order asking it to drive the user to the stairs nor to allow the composition of plan to do that. But, it may override other conditions if the manager ask for it or in the case of an emergency –ie the agent should be able to recognize an emergency state– or to ask for help in the case of an impasse. To do this it is necessary to build safety plans and be able to reasoning about them.

This is an open issue that has to be further discussed and that should be included in the new technologies for the disable and senior citizens, as well as in any agent aplication for healthcare tools.

6 CONCLUSION

Although existing solutions that increase an independent living for senior citizens are currently available on the market those are oriented to solve problems in a very poor manner and address a small subset of user's needs. As said in §1 most of them try to solve the teleassistance problems, as in [2]. We are putting forward these proposals to provide support for disabled and senior citizens people. They may be applicable to a range of levels and kinds of needs, from use by intact healthy persons and those with mild cognitive limitation, to providing support for caregivers of elders with moderate impairment and disability. Those agent systems are devised to provide aid in carrying out activities of daily living, and also performing tasks related to health care maintenance (including standardized behavioral assessments useful in medical monitoring). In addition, they will provide links to the outside world, including entertainment and information, and will facilitate communication with family and the environment.

Among the most important obstacles that new technologies (such as software agents) find in real applications in medical informatics we have: user expectations and acceptance, security and trust issues, lack of standards and integration with pre-existing health-care systems. But acceptance of such systems will increase in the future, as senior citizens will be used to interact and rely on more technological devices.

We propose here real integration of heretogeneous technologies to serve to disabled and senior citizen with problems as those described in §2 and §2.2. Also it is important to notice that there are different efforts trying to solve small problems but an integral solution has not been approached yet.

This proposal is in line with the *Ambient Intelligence* key action I in the IST FP5 and the EU Telematics Initiative for Disabled and Elderly people (TIDE) through which the EU has been funding research for creating such an environment with an specific focus in the patient centered healthcare management, the disabled and, the senior citizens.

In this perspective, the whole range of professionals involved in health care and disability can contribute to a more widespread awareness of the feasibility of newer ways and means of facing the problems connected to old age and disability. It is possible to study new ways through which scientific knowledge, the respect of autonomy, the experience of proximity with the patients, the acceptance of citizenship rights and, the application of new technologies will allow the construction of a support network that can change the lives of people who are affected by such devastating condition.

It is clear that the use of this new technological devices will help to enhance the quality of life of disabled and senior citizens, their families and reduce institutional and societal costs.

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