To Share or Not to Share *SHARE-it*: Lessons Learnt

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Abstract. The purpose of this position paper is to discuss the authors' reflections on the use of Assistive Technologies to support user's autonomy to perform the necessary Activities of Daily Living (ADL). In special, we will address the use of Agent-based robotic services.

1 Introduction

Universal population aging[1] is the most consistent and dominant population trend in this century. In all regions, the scenario projections show an aging population. Population aging has long been recognized as a cause of concern in the industrialized countries, but projections clearly show that over the coming decades it is likely to hit less developed countries even harder than it has industrialized countries because of more rapid fertility declines [9]. By 2050 the share of the above 60 age group will be around 37% in Europe.

There is a wide range of problems facing by older adults as they age. Many represent old challenges to health care providers, including chronic illnesses like heart disease, diabetes, and hypertension, as well as deterioration of physical function, high risk of falling, strokes, memory problems, cognitive decline, and loneliness. At the same time, the population of older adults is growing, giving concern as to *how* these people will get the care they need. The potential for ICTs to help alleviate these pressures and reduce prevailing concerns has long been recognized. It is within this context that we are examining the potential for Assistive Technologies (AT) to be used in order to promote the independence of individuals with cognitive and/or physical disabilities. We have to be aware that for many people with cognitive and/or physical disabilities, the use of AT devices is an essential condition to be able to keep in society.

Artificial Intelligence technology, embedded in an Ambient Intelligence environment, offers the potential for innovative solutions, spanning such areas as

[1] As measured by the mean age of the population or the proportion of the population above age 60.

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sensing and sensory perception, computer vision, planning, reasoning, smart homes, robotics and human-robot interaction. We believe that in the near future ageing and disabled people will use smart AT to perform daily living activities, socialize, and enjoy entertainment and leisure activities.

As reported in [4]: "*The ageing process progresses differently in each person. It is shaped by genetic disposition but as well by a number of contextual influences and individual behaviour... This understanding of human development and ageing as a bio-social co-construction, implies that human ageing is not determined but modifiable; in other words, it shows substantial plasticity ...*". This introduces the complexity of the situation: none of us ages in the same way and therefore there is no general solution to the problem of supporting independent living for elders. Still, the same study points out that:'*Older people can adapt more or less well to some of the biology-based losses, while other losses can be compensated by technical aids*". This opens, in our opinion, the floor to bring personalization into the game: every possible user profile should be supported by the *appropriate* answer by the system.

1.1 Plan of the Paper

We do believe that the use of an agent-based approach [3,8,10] is one possible and reliable answer to this complex problem. We give an insight to the main elements of the *SHARE-it* architecture to allow a discussion on the decisions made to implement it. This paper has the following structure: In §2 we give a brief introduction to the *SHARE-it* project. This will serve as a frame for the authors' reflections on AT. In §3 we deal with the description of an agent-based robotic platform, this is called *i-Walker*. We will focus in §4 on the main lessons learnt during the *SHARE-it* experimentation with real users. In §5 we give some final remarks and put some open questions that we like to try to answer.

2 *SHARE-it*

SHARE-it was a research project funded by the European Commission in the context of the 6^{th} Framework Program. The project started in January 2007 and ended in December 2009. The project kept on track and produced a series of prototypes of mobility platforms and created a test that go well beyond the *state-of-the-art* of assistive systems for older adults. The aim of the project was to develop a scalable, adaptive system of *add-ons* to sensor and assistive technology so that they can be modularly integrated into an intelligent home environment to enhance the individuals autonomy. The system will be designed to inform and assist the user and his/her caregivers through monitoring and mobility help. Thus, we plan to contribute to the development of the next generation of assistive devices for older persons or people with disabilities so that they can be self-dependent as long as possible. We focus on *add-ons* to be compatible with existing technologies and to achieve an easier integration into existing systems. Both hardware and software applications have been developed to allow easy integration with other ICT building blocks, thus becoming part of a general assistive environment. We also aim at adaptive systems as transparent, and consequently, easy to use to the person as possible. The project covered both theoretical and practical aspects on AT. The main objectives were:

O1 To explore the benefits of the concept of situated intelligence to build elements (*add-ons*) that will enhance the autonomy of the target user group in their daily life in their preferred environment.
O2 To investigate and implement innovative forms of shared autonomy.
O3 To build appropriate add-ons to standardised technologies to provide ubiquitous sensing, computation and assistance.
O4 To build adaptive interfaces for the target group.
O5 To target the various human-delivered assistance and caretaking services as effectively as possible.

Project results include four mobility platforms fully deployed: CARMEN, *i-Walker* (see §3), Rolland and, Spherik , the deployment of the architecture in a test site namely *Casa Agevole* in Rome [12]– an agent-based architecture and open source software components. Disabled and older people are constantly faced with the choice of remaining at their preferred environment with a *care package* to meet their needs or being institutionalised. In *SHARE-it* our idea was to provide the means to personalize this *care package* to the needs of each user according with his/her diagnosed profile. One of the main achievements of this project was the experimentation. Where 21 Italian volunteers with some cognitive and/or physical disabilities were exposed to this cutting edge technologies in order to solve some typical ADL in four different *Scenarios* that were designed *ex profeso* for showing the *SHARE-it* Architecture capabilities in real settings [2]. The experimentation phase took place along the autumn of 2009.

3 *i-Walker*

In our aging society, many people require assistance for pedestrian mobility. In some cases, assistive mobility devices require a certain degree of autonomy when the persons' disabilities difficult manual control. However, walkers or rollators are not supposed to overtake *full* control on human mobility, as this is reported to lead to loss of residual capabilities and frustration and, in the case of walkers may cause some incident. Furthermore, the level of control a person can exert over a mobility platform may be indicative on his/her condition. Consequently, it is important to rate the mobility performance of users of walkers to check their condition and evolution. Also those measurements can be used to evaluate the quality of different control strategies and environment configurations.

With this context in mind, we introduced in [5] the design of an integrated architecture aimed at helping citizens with disabilities to improve their autonomy in structured, dynamic environments. The main element of this architecture is an intelligent agent layer that mediates between different technology components (robotic devices –as the *i-Walker*– ubiquitous computing, and interfaces) in order to provide the subject with the necessary degree of independent mobility to benefit from different assistive services and to reach goals determined by either the subject himself/herself or by medical staff.

The agent based control system provides an excellent means to model the different required autonomous elements in the patient's environment (from control elements in the wheelchair to care-giving services). Agents probe to be efficient in coordinating heterogeneous domain-specific elements with different levels of autonomy. Addressing the mobility problem and keeping in mind that different users need different degrees of help, a part of this agent based control layer has been focused on the development of a shared control for the robotic wheelchair that adapts to the user needs.

The *i-Walker* is an assistive device with four conventional wheels and two degrees of freedom (see figure 1). Two of these wheels, the ones placed closest to the user, are fixed wheels driven by independent motors. The other two wheels, the ones placed on the front part, are castor-wheels. They can freely rotate around their axis and are self-oriented. The *i-Walker* has two handles, that the user holds with both hands, to interact with it. The *i-Walker* is a passive robot as it will only move if the user moves it [6,1]. The mechanical analysis of the *i-Walker* is focused on the interaction between a generic user and the vehicle, in addition to how the rear wheel motors -which are the only active control available- can modify the user's behaviour and his/her perception of the followed path. For safety reasons, these motors will never result in pulling the *i-Walker* by themselves.

The *i-Walker* has been designed to be passive, cooperative and submissive. *Passive* because it can only adjust the facing direction of its front wheel, *i.e.* it can steer. However, it has no forward drive motors and so relies on the user for motive force. This allows the walker to move at the user's pace and provides for the user's feeling of control. *Cooperative* because it attempts to infer the user's path and uses this inference to decide how to avoid any obstacles in the user's path. *Submissive* because it monitors the users to see if they are resisting the actions (steering/braking) selected by the walker. If they are, the movements are adjusted. This cycle continues until the user agrees with the motion (*i.e.* does not resist it) or manually over-rides it. This interaction forms the basis of the feedback loop between user and agent. Similar approach can be found in [13] The manual brakes have also been replaced with an automated braking system. The *i-Walker* can sense the user's steering input *via* sensors in the handles that detect the difference in force on the two handles: *Pushing* with more force on one handle (left or right), the walker will turn in the opposite direction and/or *Applying* of equal force on both handles will move the walker straight forward or backward (which direction can be determined by the *i-Walker*'s wheel encoders).

One of the main objectives of *SHARE-it* is helping the users in orienting them when handling the *i-Walker* in a known environment. The user will receive help from a screen, but the innovative idea will be steering by moderate braking, for helping in navigation. Apart from the multi-modal (in particular speech) interface, we will experiment with moderate brake on the *i-Walker*'s wheels to

Fig. 1. *i-Walker*

gain the experience on *how* to better guide the user by allowing s/he sharing with the computer the steering actions.

3.1 Agent Layer

The *i-Walker* sensorization provides the means to precisely track the user's intention in every situation. All the information gathered supports the agent layer that will process this data and use it to provide the services that users might need using the computer device attached to the *i-Walker*. The agent layer delivers three main kind of services: monitorization, navigation support and cognitive support. The monitorization services gather all kind of data from the sensors (walking behaviour, forces exerted, environment, localization if available, ...). The information related to the user will be processed and analysed by medical partners with possible rehabilitation uses. Also, with the step behaviour and forces on the handlebars observed the agents can determine the user intention, be it in navigation terms or even if the user is trying to get up from a chair or just trying to get the walker closer to the place where they are resting. Monitorization also covers security issues, like being aware if the user or the *i-Walker* fall to the ground, and taking the according measures. Among the navigation services the users have on disposal a map of the environment and their localization on it. They can ask for a route to reach some destination and real time indications to follow it. If navigation is interrupted by non avoidable obstacles, the agents can suggest a new route or offer to ask for help to a caregiver. The way help is requested, depends on the environment (tcp msg, sms,...). The *SHARE-it* agent layer offers a series of cognitive aids focused mainly on memory reinforcements and ADL support. The user has an ADL agenda, a skeleton of daily activities that the user performs like waking up, going to the toilet, having breakfast, etc. The monitorization services keep track of the sequence of places (*i.e.* rooms) that the user has visited, and the order is also tracked, so for instance the agent *knows* if the user has visited the kitchen for breakfast after waking up. Comparing his daily behaviour with the user's usual agenda, the agent can send some activity reminders to the user in case he forgot.

The user agent can also trigger help request messages to the caregivers if some abnormal agenda activities happen, for instance if the user has not visited the kitchen in all the day, probably meaning that the user has not had any meal at all. There will be a special attention to the medical reminders, like having the medication at the right time, RFID tags on some environment items like the medicine box will support this service. Some people with moderate or heavier cognitive problems, can forget how to perform some ADLs or just get confused while performing them, so they can ask their agent a tutorial on *how* performing a daily activity (*i.e.* washing your hands) [11]. The ultimate goal of the interaction between robotics, Agent Systems and the user is to enhance autonomy and up-grade the quality and complexity of services offered. The degree of control exhibited by the *i-Walker* control agent depends on the abilities of the user at each time and situation. Nevertheless, some important topics as safeness and security have to be redefined in the future in order to broaden the applicability of this approach [7].

4 Lessons Learnt

Independent living means something different to each older adult. For some it may mean not depending on others for assistance with daily activities. It might also mean having the mobility to retain an active life, or simply the ability to live at home, as opposed to living in a care facility. There is considerable evidence that people with disabilities and older people would rather stay in their own home than enter institutions, and in some cases, such as dementia, it is even essential that the person is in familiar surroundings. With this in mind we designed a set of experiments trying to emulate the real conditions of a *normal* house with the minimal infrastructure to support an Intelligent Ambiance. For the experimentation phase of the project one the most relevant lessons learnt is: *Robotic interaction should not replace human interaction but rather improve it.* This has been already observed by other researchers but when the user has to share some of his/her autonomy with a machine able to make decisions and take actions as it is the case in *SHARE-it* – the user should be able to trust and feel safe using it in his/her daily activities without the participation of skilled individuals supporting the continuity of the services. Evaluating the impact of in-home technologies on older adults is crucial. An important element in testing architectures that are meant to support elders in performing their ADLs is the test site. In our case we had the opportunity of using an existing facility called *Casa Agevole*. This was very both a challenge and an opportunity as it was not originally designed to have for example a standard domotic network as most of existing houses. *The test sites need for a previous benchmarking.* Still, there is no enough experience in the designing of those test sites, therefore if becomes quite complicated to have a good picture of what an appropriate test site should look like. The main reasons to have in hand a benchmark are: (a) To ensure the home-based technology is usable and it is receptive to users' needs; (b) To ensure seamless integration with the users' ADL, minimizing any negative impact on the users; and (c) To ensure *appropriate* interaction.

The ethical and legal considerations in the design of *SHARE-it* like architectures and/or social assistive robots should be considered as a kernel element for future developments funded with public resources. That is to say *the robot ought to act ethically*. For example, if the user being assisted is under an emergency situation, where does the robots responsibility ends? Is it only to send the alarm messages? In the case of an emergency situation, who is in charge of the robot? Is the user or his/her caregiver? Who is the legal responsible for the robots autonomous actions?

5 Conclusions

SHARE-it thanks to its Experimental Phase allowed us to identify the value of the assistive services, created along the life of the project, to serve the objective of supporting people with disabilities so that they can be self-dependent as long as possible in their *preferred* environment.

One of the most challenging aspects of this whole enterprise has been to establish a measure of *success* as at every step a new aspect or interaction to be considered appeared in the field. No benchmarks for fully integrated environments exist and the ones benchmarking individual elements are not effective for the scenarios addressed by *SHARE-it*. We had to develop our own approach.

The experimentation phase allowed us to identify the key role of *Personalization* through Ambient Intelligence in the development of AT for the elders with some kind of disabilities. It is well know that Ambient Intelligence implies three relatively new technologies: Ubiquitous Computation, Ubiquitous Communication, and Intelligent User Interfaces. In our case the interfaces were one of the most crucial points in this experimentation. In our setting the interface has been under a constant improvement during the process. Human-Computer Interfaces for AT are a field were attention should be focused.

Assistive technology devices and services enable (elder) individuals with disabilities to participate in society as contributing community members. It is our understanding that we are now at the very beginning of new research enterprises as we are able to better describe the problem as our model has been enhanced by very fruitful interaction with real users using the technology and, therefore, we are prepared to pave new ways for solving them.

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