Enabling Social Interaction Through Embodiment in ExCITE

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***Abstract*—The emerging demographic trends toward an aging population involve an unflagging research of ways of assisting elderly people to stay independent for as long as possible. This means to be active at home and in the labour market, to prevent social isolation and promote societal inclusion. Both ICT and robotics technologies can contribute to help achieving these goals. This paper introduces the aims of the Ambient Assisted Living project ExCITE whose main objective is to enhance a robotic platform for telepresence with features enabling social interaction from a domestic environment to the outside world. The whole ExCITE project uses a user-centered approach hence it evolves around an intensive evaluation to be performed in situ, on a PanEuropean scale. An existing prototype, called Giraff, is to be deployed to targeted end-users, and refined taking into account outcome of the evaluation. This paper introduces the objectives of ExCITE and offers a description of its initial activities particularly focused on the user evaluation.**

I. Introduction

The emerging demographic trends toward an aging population demand new ways and solutions to effectively assist elderly people and increase their level of independence. One particular aspect of this problem, which is a great concern among the elderly, is related to the sense of isolation and loneliness, or to the perceived risk to become a burden for friends and family, and/or to potential harm for their financial security.

In line with these emerging needs, the European Commission is devoting attention to promote new tools for "facilitating social interaction" and more in general to improve the quality of life of old people. In particular this topic has been chosen as the focus of Call-2 of the EU Ambient Assisted Living (AAL) Joint Programme. This paper introduces a project, named ExCITE, generated within this specific Call that is now starting its implementation steps.

In order to introduce the ExCITE idea we will first create the context for the description by introducing the motivation of the project and some of the connected research issues.

a) Ageing and Social Isolation: Loneliness is the subjective evaluation of a situation of restricted social relationships and is associated with an unsatisfactory level of communication and closeness with others. There is wide evidence that loneliness and social isolation increase with age, resulting from personal (health, economic status), interpersonal (distance from relatives, loss of a partner or close friends) and structural factors (external or environmental factors that influence social activities). These circumstances have a negative effect on the perceived quality of life of old people. To contrast negative feelings, social networks can provide both a real help to old people (e.g., household tasks, shopping for groceries, or other necessities, etc.) and instrumental assistance to older persons who need it [1]. Conversely, social isolation is based on the absence of a network of relationships and on limited integration within society (e.g., [2], [3], [4]). There is a strong association between social connection/isolation and physical, mental, and emotional health of older people [5]; specifically, social isolation increases the risk of morbidity and mortality [6], psychological distress, depression and suicide [2], and decline of cognitive function [7]. Many studies also show that social networks matched with leisure activities and physical exercise, prolong life, improve physical health in general, and decrease the occurrence of specific age-correlated diseases (e.g., cardiovascular disease) [8].

Social role involvement is a factor not only in slowing age-related decline in physical health, but also in reducing risk for disability in Activities of Daily Living levels. In this respect, it is important to promote social participation of older people [9]. Current ICT technologies can help older persons with physical and/or cognitive problems to communicate and to socialize with others by developing acceptable domestic services that reinforce social ties within their social network. Among innovative technologies an increasing role can be played by service robotics. Telepresence and social assistive robots have been proposed, for instance, as a form of assistive and communication devices that contribute to the maintenance of social participation in old age – see for example [10].

b) Social Assistive Robots: Social robots have the aim of supporting users via social interactions instead of physical ones and represent a robust subarea within the robotic community ([10], [11]). Goal of the area is to synthesize robots endowed with a level of utility and support obtained by mainly stressing their interactivity with the human.

The idea of the social robot for old people at home has been, for example, explored in the Nursebot project at Carnegie Mellon University that have produced a progression of robots, like Flo [12] and Pearl [13], focusing on different aspects of interaction. Flo is a prototype of a home robot which provides information related to activities of daily living obtained from the Web and offered to the person through speech synthesis. It also introduces the idea of the remote care-givers establishing a "tele-presence" in people home, by relaying back video and audio streams. Pearl is a second version in the same line, explicitly tailored for assisting old people in routine tasks such as eating, drinking, taking medicine, using the bathroom or visiting a doctor. Specific functionalities for guiding a person in an nursing home have been demonstrated together with abilities to support simple dialogues. Similar projects have been generated within the last ten years sharing the context but investigating different research issues – for example the idea of a robot moving in an "augmented environment" with sensors and other intelligent capabilities has been investigated in projects like ROBOCARE [14] and PEIS ecologies [15].

Other projects have produced demonstrators of service robots that focus on the complexity of the capability and tasks that robots can perform within home environment with real people. Care-O-Bot [16] is, for example, a mobile robot for home services. It shows examples of support to both manage continuous activities of daily life and monitor health data of the person. The demonstrator also implements simple dialogues focusing on medicines to takes, and on the ability to do an emergency call if needed. Examples like this one provide an intuition of the current status of the technology as well as of the improvements obtained over the last years.

There are also examples of actual products that are focused on specific tasks and add flexibility to continuous assistance of people. For example the RP-7 robot of In-Touch Health [17] broaden the concept of endpoint terminal allowing physicians to extend their presence across the entire healthcare delivery continuum – from primary and outpatient care, to acute care, rehabilitation and long-term care – with the same device. Again this tool shows the variety of solutions that are currently investigated and the potential which is behind the "robot (r)evolution".

c) The ExCITE Approach and this Paper: The work described in this paper is an introduction to the activities of the EXCITE project. The strategy followed within the project is the one of selecting a commercial product with high potentials, the robot Giraff [1] for remote teleconferencing, and adapting it to the goal of the AAL call of favoring the social interaction of old people by empowering the current functionalities with a user centered study. The reminder of the paper is subdivided into two main sections: Section II overviews the project's aim, and Section III introduces the pursued user centered approach also anticipating the variety of problems addressed in the project in order to robustly serve the needs of the old population. A concluding section ends the paper.

II. THE EXCITE IDEA

The basic idea pursued in EXCITE is to help developing a technology able to facilitate social interaction of people potentially isolated (in their home or in a health institution) in order to increase their level of social participation thus diminishing the sense of loneliness. Specifically, the project aims at addressing social isolation and reducing loneliness by bridging distances, facilitating interaction and communication through the implementation of selected ICT technologies on top the robotic platform.

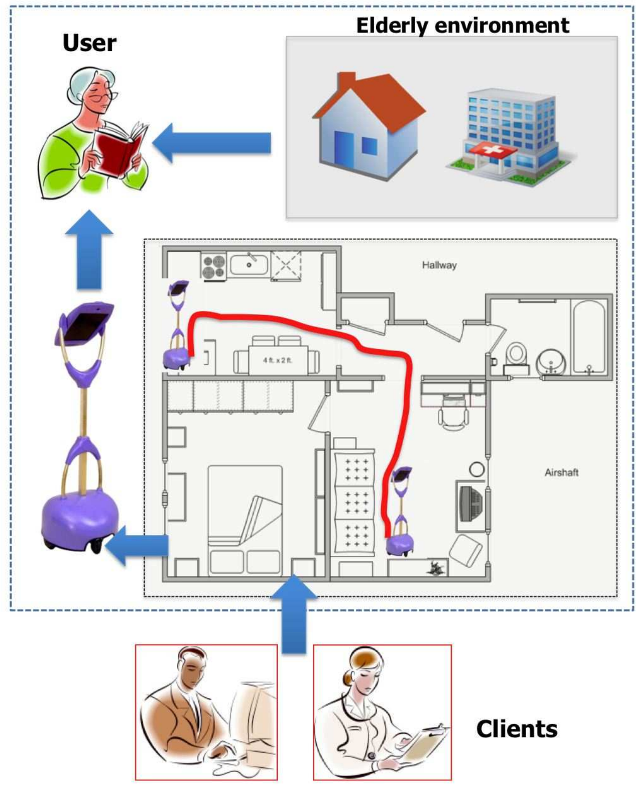

Fig. 1. The EXCITE overall idea

The use of these systems as a tool to enhance social interaction for the elderly has been advocated in [18]. The idea of the project is simple but rather effective. We plan to use a remote-controlled robot able to move within the home environment and endowed with a teleconferencing system (see Figure 1). The robot is operated by a person (relative, caregivers, friends), the *client*, who wants to contact the old person (*user*) in his/her living *environment* (e.g., home, health care institution, etc.).

The client can drive the robot through the user's environment to reach different locations, by using a simple software installed on a computer. The intuitive EXCITE idea is to employ relatively simple but robust technology, which offers limited but consolidated functionalities and to investigate possible problems/challenges that may arise from a deployment in real contexts. This pragmatic approach can then provide useful suggestions and guidelines to further improve the robotic features as well as to realize automatic functionalities that correspond to real users' needs and expectation.

A. Telepresence to foster social participation

Telepresence has long been advocated as a means to enable virtual face-to-face communications for people located at

[1]http://www.giraff.org/

different places. A newer variant of telepresence has recently emerged which proposes to integrate ICT technologies onto robotic platforms and to enable actuation in a remote location. So far robotic telepresence has made a debut in the deployment of robotic systems in dangerous or unreachable environments. However, a number of systems are starting to emerge that advocate the use of robotic telepresence in a domestic or office environment. The use of such systems as a tool to enhance social interaction to cope with the aging society issue is still relatively novel. However, used as a device to increase social interaction, robotic telepresence could be particularly suited to an elderly audience for a number of reasons. Firstly, the elderly interacts with the robot in a natural and intuitive manner as little additional learning is required for the elderly. Secondly, the client connecting to the robot from a remote location gains a greater level of control which is currently not possible in desktop type telecommunication applications. In particular, this greater level of control allows the client to move in the environment. Thirdly, this particular type of technology is suitable for a diverse group of elderly including those who are very mobile (with multiple residences) who want to maintain contact with their family kin etc.; as well as those who are less mobile and want to connect to the device to gain a greater sense of mobility and access. Despite this potential, the number of existing systems which advocate better social interaction have indeed only been subject to either little or no end-user validation with an elderly audience.

Telepresence and mobile telepresence concepts have been envisioned, built and even commercialized since the 1980s. Telepresence provides for virtual face-to-face communications for people located at different places. However, it limits visual communications to pre-established views and does not allow users the “walking around” experience. Mobile telepresence or “tele-robotics” – the combination of teleoperation and telepresence – offers this additional “walking around” capability and is the key contribution that the Giraff concept achieves for home care.

An example of fixed location telepresence for home care is the ACTION platform, an EU project that designed a video conferencing responsive support service for caregivers of elderly people. This project was driven by University College of Borås and is now deployed in the city of Västerås, Sweden. The product has achieved some commercial success but has been held back by its lack of mobility. Examples at large of tele-robotics today include concepts such as Robonaut (an extravehicular activity astronaut equivalent), Robovolc (designed to perform autonomous and/or semiautonomous exploration and measurements in a volcanic environment), and PeopleBot (from MobileRobotics, designed for applications such as business promotion, monitoring and entertainment). An example specific to healthcare is a device developed by Fatronik Tecnalia in Spain. Initially developed for multipurpose service robotics, this prototype was subsequently applied to assist elderly people living at home. Assistance includes tasks such as user walking, reminding, providing environmental information, controlling environmental security, providing health services and communicating with people (doctor, assistant, family). Perhaps the most recognized telepresence robot today is the already mentioned RP7 by In-Touch Health designed to be used in hospitals and other acute care facilities.

Giraff is not intended to replace the human presence or intelligence, but rather to extend human presence for purposes of social interaction with people who probably are most in need. Focusing on a simple audio/video communication system on top of a mobile platform, Giraff ensures a reliable service and will allow an effective assessment of the tool. One of the limitations of current robotic devices is that they do not always guarantee a continuous and long-lasting functioning, which often prevents from experimental studies with real subjects. On the contrary ExCITE is based on a simple but very robust technology that will support an in depth investigation of the following research aspects:

– Advancement of mechanical design to be optimized for the home environment;
– User interface and navigation features that allow the use even by informal caregivers with little training and experience;
– Research on the shape of the product that help the user acceptance and trust;
– Understanding of human factors related to acceptance, usability and accessibility by users;
– Effectiveness of the proposed tool to decrease the sense of social isolation and loneliness.

These aspects will contribute to further develop the robotic system thus enriching its functionalities in line with a user-centered approach [19], [20].

B. The Giraff platform

Giraff is a remotely controlled mobile, human-height physical avatar integrated with a videoconferencing system (including a camera, display, speaker and microphone). It is powered by motors that can propel and turn the device in any direction.

The robot has been designed with a low center of gravity, ensuring stable operation even on wheelchair ramps. The Giraff’s 14 kg weight and integrated carrying handle allows it to easily be placed in a car or carried up stairs. A 33.8 cm LCD panel with 1024x768 resolution is incorporated into the head unit. The LCD panel provides a specially designed bright image and a near 180 degree viewing angle for use in a mobile application with highly variable viewing angles. Video is magnified to fill the screen so that the other person’s face is visible and is approximately life size. The head unit can tilt and pan to simulate eye to eye contact using servo motors.

The base moves using a differential drive movement system. A patented suspension system allows the 15 cm wheels to climb small obstacles and rugs while maintaining the stalk in an upright position. The drive wheels are driven by high power motors enabling speeds of up to two meters per second, a brisk walking pace. Both drive motors use encoders for accurate positional feedback. As for the sensors, development is currently in process to add 4 IR sensors for use in collision detection and avoidance. A remote user can charge the Giraff by driving it onto docking station. The docking station charges the batteries in under two hours. A full charge is sufficient to allow the Giraff to wander untethered for over two hours. Extended use batteries with a four hour life are also available. The Giraff can also be used while being charged, although naturally it must stay on the docking station.

Fig. 2. Examples of Giraff prototypes

The Giraff is accessed and controlled via a standard computer/laptop over the Internet, using an application that can be downloaded for free from the Giraff web site. From a remote location a person with no prior computer training can "visit" a home and intuitively navigate the Giraff down hallways, through doorways and around tables and chairs. Visitors can also look around via a pan/tilt/zoom camera, and can be seen and heard in real time via a life-size portrait image from their webcam. They can even adjust the Giraffs height to "sit at a table or bedside allowing true face-to-face conversations in all settings. Visitors do not steer the device as they would driving a car, but rather just point in the direction they want it go and leave the steering details to the Giraff. The device can be directed to a charging station when not in use. The main philosophy is that mobility is a fundamental requirement for healthcare; caregivers must be able to go to where the resident is, look around and assess the home environment, and in the case of emergencies connect independently and see what is wrong. The fixed nature of a computer or other videoconferencing devices limits their purpose for home care. Rather, Giraff overcomes the limitations of traditional videoconferencing equipment through mobility by completely removing the user interface from the resident home. They simply receive a Giraff visitor as they would an in-person visitor (see Figure 2).

III. The ExCITE workplan

Goal of the AAL programme is to favor a rather quick return to market (hopefully within two years from the end of the project). Hence a rather straightforward plan for the ExCITE project has been conceived. Specifically, our project is grounded on the existing platform and the idea is to empower it according to the result of a phase of continuous interaction with potential users.

A. *User-centered approach in ExCITE*

The implementation of successful ICT solutions to advance elderly's social interaction requires social practice-oriented approaches to integrate user experience and interaction design. In this respect, it is necessary to understand and model the structure of older person's social relationships in realistic use cases that can significantly contribute to the design of appropriate technological interventions and really improve their acceptability by end-users. With regard to this crucial point, it is important to assess the needs of the elderly in both roles (client and end-user). Therefore, the driving concepts and methodology of this project are centered on the user based evaluations and the elicitation of user requirements when using the prototype. The methodology is highly inspired by a user-centric approach used to prototyping, validating and refining solution in both multiple and evolving real contexts called the Living Lab approach. Such validations will occur in a cyclic fashion where the prototype is deployed in a number of end-user sites, qualitative and quantitative data of user feedback is obtained, changes to the prototype and the necessary infrastructure are accounted for, and the prototype is re-deployed. For this methodology to be successfully applied, the ExCITE project proposes a strategy which involves the end users and researchers in a tightly knit collaboration. This approach is also in line with the recent attention towards end users consideration within the research area of human-robot interaction for socially assistive applications.

Again in this area the need to involve competencies from several heterogeneous disciplines [10] is a crucial aspect, as well as the attention toward social interaction between human users and robotic agents. For example, in [21] it is highlighted how observation and behavioral analysis of human-robot social interaction in real environments are necessary in order to take into consideration all the divergent factors pertaining to the design of social robots.

B. *Implementing different forms of interactions*

The robot Giraff and the client/server architecture of the ExCITE idea allows to deploy and consequently to experiment different forms of interactions. A brief outline of these types of interaction is given in Table I. The combination of the possible instantiations will guarantee the different "flavors" of possible interactions to be evaluated. The first column of the table indicates the type of client who can remotely operate the robot. In particular it is worth highlighting that family members could include both young (children, grandchildren) or elderly (spouse or sibling) persons. The second column indicates the type of end-users situations, while the third column shows the possible location for both client and end-users.

It is worth noting that in certain cases, there may be several clients accessing the same Giraff system at different times. This is particularly true when the Giraff is deployed in a public housing facility like a nursing complex. In other cases, it may be the elderly acting as the client user contacting other elderly, such as a spouse or sibling. The term "Organisations" in the table may refer to collective activities (such as social clubs).

TABLE I
DIFFERENT FORM OF INTERACTION WITHIN EXCITE

Client-User	**End-User**	**Locations (Client/End-User)**
Family	Elderly	Residence/Residence
Elderly	Organisation	Residence/Organisation
Health Professional	Elderly	Health care facility/ Residence

The different combinations which can be obtained by considering the elements of the table, offer a quite rich scenario of study. Indeed, the use of robots in real settings can pose different problems in technology and/or user-interaction which depend on the specific scenario reproduced. In this light, the EXCITE project will devote a great part of the work to the realization of an experimental study which will cover as much as possible the various possibilities presented above. In addition, we plan to replicate the evaluation of the EXCITE system in different nations of Europe so as to detect also cross cultural differences on the acceptance of robotic assistant [22].

C. Towards an evaluation with users

As already said, one of the key aspects of the EXCITE project is the use of a user-centered approach, in order to deeply involve end users in the evaluation of specific aspects of the technology which may prevent from an effective deployment into real world contexts. Indeed, the primary objective of the EXCITE project is to evaluate user requirements for social interaction via robotic telepresence, and develop insights around the usability and acceptance of this technology. As mentioned, this evaluation will be performed in different European countries and reproducing different combination of interaction as specified in Table I. The project schedule includes a series of pilot applications where tests on the platform will be performed. The diverse forms of possible interactions through Giraff are given in table I.

To this purpose a large part of the EXCITE contribution will be the evaluation with potential users. We are currently organizing the evaluation according to two different dimensions:

– *Client – System* interaction
– *End-user – System* interaction

In order to analyze the client-system interaction both relatives of elderly users and health professional will be contacted for the recruitment. These participants will be then subdivided according to their level of expertise in using technology. The system-user interaction will be tested involving both elderly people living in their own homes and those who reside in health care facilities.

1) Client – System interaction: It is worth reminding that clients are people far away from both Giraff and the old person that interact with the person trough Giraff. The aspect to start evaluating is mainly related to the usability of the client interface and the navigation methods it allows related to the tele-operation of the robot. Indeed aspects related to both easy of use and safety are particularly relevant to be tested in a real setting. In [23] for instance a pilot study has been carried out, which evaluates two conceptually different interfaces for tele-operated mobile robotic systems with a small set of trained and untrained operators. That paper provides useful suggestions that can be considered for augmenting the operator performance. The question of safety of robot operations has been investigated in the rescue domain, where for instance [24] examined the user interaction and identified potential information displays that could reduce the number of potential incidents. Authors identified some guidelines for information display of tele-operated robots. In line with these studies, we will investigate the usability features of the client interface providing suggestions for the technological improvements of the Giraff system (client side). Different types of client (e.g., with different level of expertise) will be also involved in the study.

2) End-User – System interaction: From an end-user perspective we envisage the study of three main aspects: *usability*, *user acceptance* and *perceived social isolation/loneliness*. The usability of the system will be evaluated through heuristic evaluation [25] and observational studies aimed at understanding problem in the user system interaction. Results from this first study will be used to refine the technology accordingly.

a) Acceptance: User acceptance has been defined as "the demonstrable willingness within a user group to employ technology for the tasks it is designed to support" [26]. A number of theoretical models have been widely used in the literature for modeling user acceptance of technology. TAM [27] is one of the most widely used models of technology acceptance of end-users. It suggests that *Perceived Usefulness* and *Perceived Ease of Use* influence the *Behavioral Intention* to use a system through the mediation of *Attitude*. In addition the *Actual Use* of the system is predicted by the *Behavioral Intention*. A more recent and comprehensive formulation of the technology acceptance model is the Unified Theory of Acceptance and Use of Technology (UTAUT – [28]). Within this model the constructs *Performance Expectancy* and *Effort Expectancy* correspond to "usefulness" of TAM. These last two constructs are direct determinants of Behavioral Intention. In the EXCITE user-evaluation effort we will take as a reference point the constructs of both models in order to examine the acceptance of Giraff robotic platform, in particular by concentrating on those constructs that are more suitable for the telepresence case.

It is also important to study the psychosocial impact of a technological aid on its users in order to identify the reasons for its use or its abandonment and to recognize problematic areas. Psychosocial factors may be crucial in determining the degree of satisfaction of the user; sometimes the abandonment of an assistive device is due to technical problems but there are several cases where factors such as personality and motivation can have an important effect. Satisfaction and frequency of use are determined by real costs and benefits related to the use of assistive device [29]. Additional variables that can be relevant for the acceptance of the robot are enjoyment, perceived need of assistance as well as privacy. Finally, it is important to consider that acceptability of robotic devices in the home setting depends also on the cognitive, affective and emotional components of people's images of robot [30].

Within EXCITE we are trying to extend these considerations to the relationship between older people and the Giraff system by developing *ad hoc* questionnaires to measure to various aspects.

b) Perceived social isolation/loneliness: One of the most important aspect of the EXCITE project is the idea of using telepresence to diminish the sense of loneliness of elderly people and foster their social participation.

Indeed, elderly people tend to feel isolated and their social participation decreases gradually with the years. We can speculate that telepresence robotic systems can significantly help to increase social inclusion of older persons by communication services such as videoconferencing tools that offer an immediate benefit to elderly people enhancing communication with others. However, when dealing with the implementation of ICT and robotic solutions to advance older people's social interaction it is necessary to investigate their social participation, isolation, social and familiar support perceived. In order to understand to what extent is an older person alone, we plan to administer *ad hoc* questions as well as an existing validated loneliness scale (e.g., UCLA Loneliness Scale). This instrument is a most commonly used self-report loneliness questionnaire (20 item) for the assessment of subjective feelings of loneliness or social isolation [31]. The use of these instruments before, during, and after the "Giraff experience" will allow to assess the potential beneficial effect of telepresence as a mean to reduce social isolation.

Overall, all the above mentioned aspects will be assessed through experimental session focused on studying user interaction with the Giraff robot, focus groups with elderly users and caregiver (formal and informal), questionnaire, as well as possible experience diaries that users will be asked to compile during the period in which the robot will be in their environments.

IV. CONCLUSIONS

The EXCITE has recently (July 2010) started its way to produce an empowered version of Giraff. Over the three years of project we are confident to investigate more deeply the issues connected with the adaptation of an existing tool to the need of aging population. Apart the new version of Giraff we would like also to have a solid version of the evaluation methodology which can be more widely used for diversified tools.

As for the Giraff functionalities we plan to focus on endowing the robot with basic functionalities for autonomy in order to strengthen its at home behavior, to improve the communication abilities to support mixed-initiative interaction (the current platform expects the initiative of the client) and to synthesize new services which further facilitate social participation.

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