

Towards long term acceptance of Socially Assistive Robots in retirement houses: use case definition

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Abstract—The deployment of new assistive technologies, in general, and Socially Assistive Robots (SAR) and Ambient Assisted Living (AAL) ecosystems, in particular, faces many issues regarding long term adherence, acceptability and utility. Most of these issues are due to design processes that do not take into account the needs, preferences and values of intended users. This paper presents the first steps of two regional projects involving long term evaluation of these technologies in the context of a retirement house. These projects follow a human-centred and participatory design approach to overcome usage barriers. To date, there are no research contributions in which a socially assistive robot, designed *for* and *with* users, has been tested in field trials for long term, in a real scenario. This paper describes the proposed methodology, the process already started to analyse practices and user’s needs, and the implementation of the first use case to be deployed for the Socially Assistive Robot in the retirement house.

Index Terms—social robot, ambient assisted living, human-centred design, human-robot interfaces

I. INTRODUCTION

Population worldwide is growing older, and this demographic change is deeper in certain regions, such as the South of Spain. Hence, the percentage of Andalusian people aging 64 or more will grow from 19.6% in 2015, to 28.8% in 2035 [1]. This *silver society* will inevitably lead to a higher number of people going to retirement houses, and a lower number of caregivers working there.

Providing these caregivers with new tools, to help in their daily life routines, motivates the use of different technologies that usually fall into the term Ambient Assisted Living (AAL), and that range from wearable vital signs monitors to smart houses. Among these technologies, *Socially Assistive Robots* (SAR), designed to provide assistance through social interaction [2], emerge as a promising option, due to their proactivity, autonomy, adaptability and potential acceptability. Moreover, recent studies have highlighted their capacity to act as powerful social facilitators, when correctly integrated in shared environments [3].

It is in the integration of these AAL technologies in general, and SAR in particular, where projects in this research field get

usually bogged. The main problem is usually an insufficient consideration of the needs, preferences, practices and values of *all* stakeholders, in *all* phases of the design process [4]. Ethical considerations are also very relevant, as issues regarding privacy, personal autonomy, or replacement of human contact by artificial beings may easily arise if the focus moves from technology adapting to users to the contrary [4]. Moreover, counting with users to evaluate each design phase may not be enough: users should also participate in choosing specific technologies to be integrated in their environment, and be at the centre of all design considerations. Long term acceptability, utility and accessibility are the key criteria considered in the participatory design approach adopted in this research. Finally, once the technologies have been chosen, users should receive complete training courses to guarantee a complete and efficient implantation [4].

This paper presents the initial steps in two regional R&D projects, that will last for two years, in which a complete AAL ecosystem, including a SAR, will be integrated in the daily life routine of a retirement house. The goal of these projects is to perform a long term evaluation as part of a field trials “in the wild” [5], regarding functionality, acceptability and utility, of the AAL ecosystem in general, and the SAR in particular. Aiming at achieving adequate design based on a proper understanding of needs, the project will follow a human-centred and participatory approach, involving end users in all stages of the design process. Participatory design is a cooperative design process, with a focus on enabling different stakeholders with different perspectives and competencies to cooperate. Moving away from the traditional computer and “user” notion, e.g. with AAL technologies, like smart environments or SAR, there is indeed the need for participatory design and also human-centred design. Human-centred interaction design has been described as Human-Computer Interaction (HCI) “centred on the exploration of new forms of living in and through technologies that give primacy to human actors, their values and their activities” [6]. It takes as a starting point human (elderly) capabilities, with a focus on how to

support, develop and extend people's capabilities through the latest technological developments. Focusing on the SAR, in order to achieve long term adherence, this study aims towards designing a use case and a robotic platform that covers the initial expectations of elderly and caregivers, but also serves as a tool to incrementally gather and include new social skills and abilities, based on a progressive *in situ* understanding of needs through fieldwork and experiments. It is important to highlight that the robot is going to be working in the retirement house for more than 18 months. To date there are no prior studies where the performance, acceptability and utility of a SAR, co-created following a human-centred design process, has been tested for so long. This experimentation combines the characteristics and objectives of both field trials [5], as practiced in the field of HCI, to the duration and rigour of "Pilot studies" in health research [7].

This paper describes the methodology followed to actively involve users - both residents and different profiles of professionals and caretakers - in the design process of the SAR, and how user needs were analysed. It also enumerates the set of use cases generated for the SAR from these needs, and details about the implementation of the first of these use cases in a working platform, to be deployed in the retirement house in the next weeks.

II. PREVIOUS WORKS IN SOCIAL ASSISTIVE ROBOTICS

The 2005 WHO (World Health Organization) meeting adopted for the first time a resolution on e-Health, recognizing the need for the incorporation of Information and Communication Technologies (ICTs) in monitoring and improving health, as well as in the management of health systems. In this sense, the development of tools that support caregivers and health professionals in routine and monitoring tasks, both in social health centers and hospitals, becomes especially relevant. In 2015, the WHO introduced efficiency as a new aspect to the definition of ICT care [8], making it go beyond simply improving accessibility by bringing health resources closer together.

Taking into account the WHO recommendation, SAR have become the subject of many recent studies [9], where they are used to support caregivers working with people in a situation of dependence. SAR are proposed to assume simple and repetitive tasks, leaving more time for the caregiver to provide personalized care. But, despite the existence of commercial social robots since the beginning of the 21st century with different appearances (humanoid, fictional character, companion animal, etc.), they still face many limitations in adapting their behaviour to the characteristics and state of their possible interlocutors, constraining their capacity of exhibit social behaviour to increase acceptance or even act as social facilitators. This limitation is normally imposed, among other aspects, by the reduced interaction capabilities expected by the older adults and their relatives, such as accessible and natural interfaces or content adapted to cultural and taste aspects [10], and on the other hand, by the limited use that the robot makes of intelligent elements that may exist in its environment, such

as those available in a Smart Home or Intelligent House, which could provide it with greater autonomy.

Usability and accessibility are key aspects in the development process of social robots. Thus, the main objective of interface design has to be that users, without previous knowledge or experience interacting with robots or performing any specific task, are able to relate to - or at least interact with - the robot in an intuitive, efficient and useful way. Furthermore, it is important to consider that users may be of different ages, sex, education, skills or abilities/disabilities [11]. Therefore, it is important to implement multimodal interfaces that facilitate interaction with users, avoiding accessibility barriers that hinder interaction [12].

Recent studies still show the limitations in terms of acceptability to nowadays technology. In this sense, and without losing sight of the progressive reduction of the digital gap in successive generations, there are studies that evaluate design requirements together with different stakeholders, the impact of the use of new technologies and the degree of their acceptance, taking into account, for example, the use of web applications as a record of activities [12], or larger-scale social robots [13]. In particular, the study of Winkle, et al. [14] provides a complete analysis of a mutual shaping approach by combining elements of human-centred and participatory design of a SAR. As the main outcome, a significant shift in participants' acceptance was found as a consequence of sharing and shaping the knowledge. Our study presents a similar approach, but with the assumption that not only the initial definition of the use case but also the adaptation of the robot's capabilities will be carried out by means of insights that can be gained from observing and analyzing residents' daily *in situ* contact with the robot.

III. REQUIREMENTS AND LIMITATIONS TO OVERCOME

The success of the integration of the robotic system in the real world, in a specific scenario, depends not only on the classical aspect of robot behaviour (mobility or speech capabilities among others), but also on social abilities. Therefore, factors as the interface usability and accessibility, user experience (UX), social acceptance or societal impact, among others, should be considered throughout all the project to evaluate the success of the robotic platform.

Hence, on the one hand in the present study a human-centred design methodology is followed, to ensure the adequate design and thus the acceptance of the robotic platform and social impact in the retirement house (section IV-A). The robotic platform tasks to solve as well as behaviour is co-designed with the people living and working in the retirement house. On the other hand, in order to improve the quality of the user's interaction with the robot, UX factors are considered, taking into account the user's emotions and attitudes about the robotic platform in the retirement house, as well as system aspects such as utility, efficiency and the usability and accessibility of its user's interfaces. An in-depth and iterative evaluation of the UX is going to be done during

the two-year project, adapting the robotic platform at each step to improve the user experience, as Section IV-A details.

The characteristics, abilities and capabilities of all users in the retirement house scenario are at the centre of design considerations, whether UI requirements and building accessible and usable interfaces. Indeed, elderly people usually experiment limitations when interacting with ICT. This is due mainly to the lack of previous experience with similar technologies and to natural changes associated with aging, such as diminished vision, motor movements limitations, problems with hand-eye coordination, psychomotor impairments, hearing loss, or diminished cognitive functions among others [11]. Considering that the users at the retirement house could present one or several of these limitations, the robotic platform should be designed in an inclusive way, providing an accessible interface in order to allow all the users to interact with the system with the same opportunities. To do this, the main accessibility guidelines and recommendations in HCI [15] and Human-Robot Interaction (HRI) fields [16] are followed and specified as system requirements. Moreover, our experience in previous research projects [17], where elderly people interact with robot platforms is considered for the analysis and design process.

USUS [18] is the methodological evaluation framework chosen to assess the success of the robot platform integration. This framework is until now the most complete one in HRI literature. It consists of a mix of methods derived from various HRI, HCI, Psychology and Sociology and it addresses usability, social acceptance, UX and societal impact of humanoid robots from an holistic point of view. However, one important factor is still missing in this framework: the accessibility criteria. This factor is essential when people with special needs and elderly people interact with robots. Accessibility is currently widely studied in HCI field, however it has not been included yet in the HRI evaluation frameworks. At this point, the accessibility criteria will be included as part of the HRI evaluation methodology of our study, extending and generalising the methods, techniques and guidelines used in the evaluation of Human-Computer Interfaces [15], as we already did in the CLARC project [17] with the guidelines for accessible displays in HRI [16].

IV. DEFINITION OF THE USE CASE

This section describes how user needs have been captured and analysed, to obtain a set of use cases for the SAR, along with a detailed description of the first one implemented.

A. Methodology and Life Cycle

HCI, Software Engineering, Human-Factors Engineering and Assistive and Rehabilitation Technology disciplines propose different guidelines for the design of human-robot interfaces. Most of these guidelines are considered in this work using an iterative design methodology, following a human-centred approach [19], by involving the following stakeholders in each design and development phase of the system:

- **Primary:** Elderly people, healthcare professionals and caregivers living and/or working in the retirement house.
- **Secondary:** Relatives, visitors. Healthcare professionals and caregivers not working in the retirement house.
- **Tertiary:** Other workers (e.g. management staff, external hardware and software providers).

The adopted methodology can be divided into these phases:
- *Needs analysis.* As the first phase, it consists of collecting ideas, suggestions and requirements from the stakeholders, in order to analyze the main needs at the retirement house where the SAR could be useful. The users are involved in the design decisions through a user study (Section IV-B).

- *Viability study.* It consists of viability study about the needs that can be implemented with the available technologies our team has (the SAR and the sensors for the AAL environment). The engineers are the responsible persons of this study.

- *Use Case Design.* The use case that implements each task to solve is specified in detail, describing the robot's movements, interaction components, etc. In this phase it is absolutely necessary to analyze the user's characteristics, abilities and capabilities. Based on that, a first functional-based prototype of the UIs is developed (concept design), taking into account accessibility and usability issues as it is detailed in Section III. The stakeholders and the engineers will collaborate in the use case design.

- *Use Case Implementation.* This phase involves the creation of a working prototype to be deployed and tested in the retirement house during an 18-month long field trials. The process will follow a classical prototyping strategy, in which the robot performance will be polished through successive cycles. In each one, the use case is going to be tested in the real scenario and co-design process, until the users feel the task is complete, useful and robust, being therefore satisfied with the results. In some cases a re-definition of the use case design may be required to successfully complete this phase.

- *Integration with the AAL ecosystem.* While this work focuses on the SAR, it should be considered that the robot is integrated in a technological ecosystem that is developed and deployed in parallel in both projects. Thus, the *complete* ecosystem has to be considered when defining the complete set of use cases for the SAR, to fully use its potential.

- *Evaluation.* This phase will include the functional evaluation of each use case, but also other important factors that influence the success of the robotic platform as explained in Section III. During the project life-cycle, different tasks are going to be implemented by the robotic platform and/or the AAL environment, according to the retirement home needs at that moment, and to the feedback received from the evaluation of previous use cases (as shown in Fig. 1). Moreover, once each use case has been successfully implemented and tested, the last weeks of the two-year project will focus on intensive tests of the proposed solution, in order to "validate" the design choices. In this phase, having two robotic platforms will allow keeping one working in the retirement house, while the other can be used to arrange demonstrations and short experiments in other locations.

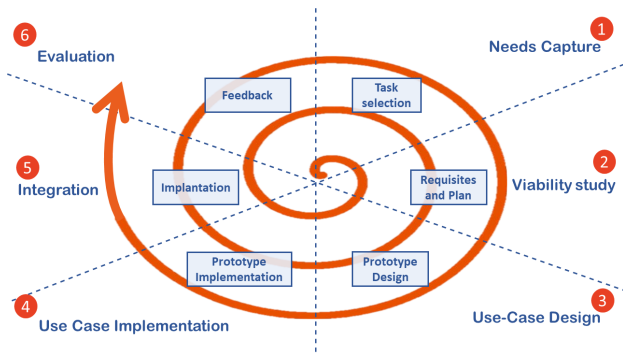


Fig. 1. Human-centred Methodology and Life Cycle.

B. First phase. Capture of retirement house needs

In this phase, the specific retirement house (Vitalia Teatinos in Málaga-Spain) needs are analysed, studying where and how the robotics' platform could be useful. By following the human-centred and participatory design approach, the Primary stakeholders and our engineers team worked closely together in this phase, as follows:

- **Observation:** Our engineering team visited the retirement-home with the principal and one occupational therapist. During the visit, the engineering team observed the environment and daily life routines in the different rooms (three living-rooms with different activities, hall, bedrooms, kitchen, etc.). They also took note of physical barriers that the robotic platform could face.
- **Focus Group Session:** The main objective is for the group (users and workers) to identify the main tasks for which the robotic platform is designed to be useful in the retirement house. Participants of this group were representatives for the Primary stakeholders, four women and four men. Three of them were residents and five of them were professionals from a range of disciplines (one occupational therapist, one physical therapist, one psychologist, one social worker and one nurse). They were volunteers and recruited by the occupational therapist. The session lasted 90 minutes and it was facilitated by one of the researchers by using HRI methods, such as collaborative mind-mapping, post-it and tasks sorting. As a result, the main needs of the residents and caregivers at the retirement home were detected and sorted according to their priorities and needs (see section IV-C).

C. Second phase. Viability study

After summarizing the main outcomes of the focus group, the engineering team analysed the feasibility of implementing these tasks. Indeed, some of the tasks were found not viable as the technology is not mature enough to offer a satisfactory and robust service. Some examples of the delimited tasks for the robotic platform, sorted according to the primary stakeholders priorities are introduced next:

- **Postural control:** check that the residents do not stay for more than one hour in the same position.

- **Selection of the menu options for lunch and dinner:** each resident can choose between two first and second courses and desserts.
- **Announcer:** the robot will announce events at the retirement house, such as upcoming meetings, celebrations or birthdays. It will also inform about the weather, etc.

Some examples of tasks for the AAL environment are:

- **Prevention of residents' falls:** detecting movements with agitation in beds, leaving the bed or going to the WC, detecting possible obstacles that compromise crossing corridors or rooms.
- **Detection of residents out of their assigned areas** (e.g. building doors, elevator, non-associated lounge): alerting of these situations.

According to this analysis of needs, priorities and viability, the engineers team decided to start the integration of the robot in the retirement home with the most simple task: the announcer (Section IV-D). The decision of starting with a very simple task is due mainly to the initial hypothesis: a successful integration of the robotic platform in the retirement-home needs a progressive familiarisation with the robot and UIs. Hence, the announcer task, in which users do not need to touch the display or talk to the robot yet, is the best task to start. The analysis process will gather users' feedback about this first task, engaging them in the understanding what they liked or not, and co-designing potential improvements. Based on these insights, next tasks will introduce new interaction challenges.

D. Third phase. Design of the first use case: announcer task

In this use case, the robot acts as an announcer: it will go through public, shared rooms in the retirement house, announcing different events as soon as it detects groups of people nearby. The robot will be teleoperated via a web interface and a joystick. Different voices will be tested for the text-to-speech system of the robot, being the first option the Microsoft Helena Spanish voice, that was successfully employed in the CLARC project. Autonomous navigation, people detection and announcing processes employed in this previous CLARC project will also be integrated and tested as a parallel process, to ease a fast deployment of the robot in the retirement house.

The following specifications provide a high level definition of the *announcer* use case:

- The SAR will be teleoperated via a web interface and a joystick.
- The SAR can navigate to two of the common rooms of the retirement house.
- The SAR will use voice, along with images and text displayed on its screen, to announce events.
- It will be possible to use the web interface to automatically upload from a file the weekly or daily agenda, and also individual extraordinary events, as long as these data are provided using a predefined format.
- Once per day, the robot will move to two selected common rooms to announce the daily agenda. It will

look for a proper location in each room to perform the announcement. The operator can instead repeat the announcement in different locations of the same room if required (e.g. when not everybody is able to properly listen the first announce).

- The robot will also be able to announce individual events, birthdays, or special anniversaries.
- The operator can type in the interface any phrase for the robot to say. Hence, it is possible to increase the information provided by the robot to any subject (i.e. weather forecast, clothing recommendations, etc.).
- Before each announcement, the robot will reproduce a characteristic, repetitive sound (e.g. a horn) as a summons to capture people’s attention.
- After the announcement, the robot says goodbye, leaves the room and returns to its starting position.

V. ROBOTIC PLATFORMS

Figure 2 shows one of the two robotic platforms, named CLARA, to be used in the project. Both platforms are similar, so it is possible to continuously keep one of them working in the retirement house, while the other is maintained in the lab for updates, or to replace the one used *in situ* if required. The proposed methodology (Section IV-A), in which user’s feedback leads to constant adjusting, redesigning and extension of the functionality and features of the robot, greatly benefits from having these two similar platforms available.



Fig. 2. CLARA robot.

The CLARA robot [17] is a SAR developed in the recently concluded CLARC EU Project (EChORD++ FP7-ICT-601116)¹. Its goal in this project was to autonomously drive a set of tests commonly used in Comprehensive Geriatric Assessment (CGA) procedures, optimising the time of healthcare professionals on high value activities. The robot is equipped with the perceptual and motor abilities required to: (i) autonomously navigate through a dynamic, daily life indoor environment; (ii) interact with people in constrained scenarios using speech, a tactile screen and other *ad-hoc* devices; (iii) detect people in its surroundings and capture their motion; (iv)

¹www.clarc-echord.eu

allow healthcare professionals to program its agenda, check performed tests, etc. using a friendly web-based interface.

CLARA robot uses the CORTEX cognitive architecture [20]. This architecture eases the robot adapting to new scenarios and incorporating new use cases. Hence, it is possible to use this robotic platform, initially designed to drive functional, cognitive and motor tests in one-to-one interactions, for a completely new set of tasks, without changing its inner software architecture.

VI. SOFTWARE ARCHITECTURE

Fig. 3 shows the components included in the CORTEX architecture of the robot for the announcer use case. These components are in charge of different tasks (monitoring, interfacing, speech generation, battery management, etc.). All of them connect to the Deep State Representation (DSR) graph, the inner representation of the world the SAR uses in CORTEX, and a shared blackboard for all modules to communicate through the so-called *agents*.

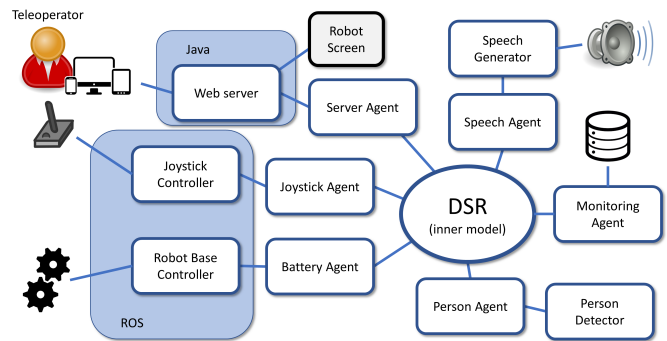


Fig. 3. Software architecture for CLARA.

Most of the proposed architecture is programmed using the Robocomp framework [20], although some modules use the widely used Robot Operating System (ROS) framework [21], and the web server is programmed using Java. The communication between these modules is implemented using the Ice middleware [22].

VII. INTERFACES

Two types of interfaces have been defined (Fig. 4): a Teleoperation interface and an Information one. The Teleoperation interface can be displayed on the assistance computer, tablet or mobile phone, and the Informative interface is shown in the touch-screen placed at the robot torso, following accessibility criteria. A web server is the element that connects them to the CORTEX architecture, using the Ice middleware (see Fig. 3), while managing the interfaces through web browsers.

For the Teleoperation interface, the server will receive user’s requests that will be translated on the execution of specific actions on the robot. These actions will be: (i) to announce a message written by the teleoperator or an event chosen from the agenda; (ii) to play some specific sound (horn); (iii) to set the robot speaker volume; (iv) to go to a room mapped by the

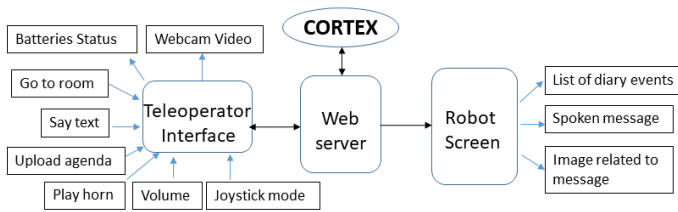


Fig. 4. Software structure for the interfaces.

robot; (v) to switch to the joystick control mode. Additionally, this interface will display to the teleoperator a video streaming from a webcam installed in the robot, as well as the battery levels for both the robot and the joystick.

For the Information interface, the web server will update visual information targeted to elders. With the goal of inclusive design accessible to all the users, this information will be associated with the messages that are given by the teleoperator for voice announcements, robot actions and the information saved in the web server, such as the agenda of events. In particular, it will display: (i) a list with a brief version of the agenda events scheduled for the day; (ii) a text message with the same words than the robot is speaking at a given moment; (iii) a figure related with the type of message or event being announced.

VIII. CONCLUSIONS

This paper describes the specification and implementation of a use case for a SAR, conceived as the starting point for an incremental design centred on elders and other stakeholders demands and expectations. In particular, a focus group has participated in this initial definition of the use case with the aim of encouraging stakeholder's involvement from the outset and eliminating false expectations at this early stage.

From the initial interviews with the focus group and by conceiving the robot and its ecosystem designed with a person-centred care as the main goal, we found that this approach could increase well-being of residents. Indeed, as reported by the stakeholders, attention should be paid firstly in allowing caregivers spending more *quality* time with elders, by reducing their workload in repetitive or simple tasks, and secondly contributing to make the robot a social facilitator, by adapting its behaviour to the elderly acceptability criteria. Following similar approaches([9], [12], [14]), the use case presented here intends to be a starting point of the study, but it has already allowed us to delimit a simple task that fulfils both premises, and that will also facilitate the definition of more complex tasks with an accessible interaction adapted to the residents' expectations and needs. As future work, other use cases will be defined and implemented in the retirement home for AAL ecosystems and the SAR during the two research project life cycle.

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