The Proof of Concept of a Shadow Robotic System for Independent Living at Home

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Abstract. In the framework of the EU funded SRS (Multi-Role Shadow Robotic System for independent Living) project, an innovative semi autonomous service robot is under development with the aim to support frail elderly people at their home. This paper reports about the user validation of the SRS concept involving 63 potential users of the system coming from Italy, Germany and Spain: in particular they were frail elderly people, their relatives and 24 hour telecare professionals. Results confirmed that monitoring and managing emergency situations as well as helping with reaching, fetching and carrying objects that are too heavy or positioned in unreachable places are the tasks for which a robot is better accepted to address users' needs. To support the scenarios executions and operation modes, the interaction concept should provide three different interaction devices and modalities for each user group.

Keywords: Service robots, tele-operation, elderly people, remote operator, user requirements, user centered design

1 Introduction

In the framework of the EU funded SRS (Multi-Role Shadow Robotic System for Independent Living) project, an innovative semi – autonomous, remotely controlled and learning service robot is under development with the aim to support frail elderly people at their home [1]. The SRS project follows a user-centered design process [2], therefore, from the beginning of the project, potential users and stakeholders of the system were involved into an iterative design process starting with qualitative focus groups, quantitative questionnaires, and ethnographic analysis aiming at finding the general features of users and stakeholders, their attitude towards new technologies, their needs and expectations from a service robot. The achieved results [2] enabled the researchers to define specific user requirements, to translate them into technical requirements, and to develop a first list of usage scenarios. It is well established that analyzing and understanding old users' perceptions when interacting with technology

devices in different scenarios is a key requirement that increases value to assistive technology, providing system developers with meaningful information for further improvements and ensuring that the system addresses to users' needs [3]. Concept and scenario evaluation is an achievable way to study products under development, avoiding being limited to studying those robots now available and autonomously functioning [4].

This paper presents the survey conducted within SRS project regarding analysis and understanding of users' perceptions about achieved requirements with the aim of validating a clear SRS concept allowing the partners involved in the technical tasks to proceed with the development phase.

2 Method

2.1 Participants and recruitment criteria

Participants in the study were the potential users of the system identified in the first part of the study: the local users (frail elderly people), and the remote operators (their relatives). They were recruited in three countries: Italy, Spain and Germany; In particular they were 30 elderly (64% female) with a mean age of 83 years (75 to 91), 23 family members (60%female), with a mean age of 54 years (29 to 70). Elderly people were recruited according to the criteria of being at least 65 years old, still able to live at home despite some difficulties in performing activities of daily living (e.g., mobility, or sensorial difficulties). Most of them received some form of assistance because of that. A short questionnaire adapted from Barber J.H., et al. 1980, was adopted for the recruitment. Relatives of elderly persons were recruited according to the criteria of being involved in some care-giving task for their relatives. Most of them cared for their parents, but some for grandparents, mothers-in-law, or old aunts. Complementarily, other participants in the study were recruited; in particular:

- Health professionals: people with high levels of experience in the geriatric field, such as geriatric physicians and nurses, physiotherapists, social workers. In particular 5 therapists (mean age 35; 2 physiotherapists and 3 occupational therapists, 3 females, 2 males) were recruited in Italy in order to obtain evaluation of the concept about any safety, ethical, and psychological issues which could arise.
- 24 hour emergency call center employees/experts: the psychological burden and time restrictions of family caregivers who usually work during the week emerged in the first part of the survey. In order to assess the idea of employing a 24-hour professional service center for tele-operation, 5 call centre employees were interviewed in Germany.

2.2 Visual simulation of the concept

Visual presentations of the concept were developed with the aim to show through simple visual examples, the hypothesized SRS concept and the selected scenarios.

The presentation consisted of three main parts: the first part about the introduction of the concept of a service robot, its main features, people involved in use and

control of the robot and the human interaction modality (figure 1); the second part about selected scenarios, and the last part about the aesthetics of the robot. Before presenting scenarios, personas and situations were introduced and described. Personas also were created on the basis of results achieved in the first user require-ment study and in the ethnographic study conducted in parallel. Then four scenarios were presented by showing and explaining sketches to participants. Table 1 reports the main user requirements achieved during the first user survey, the hypothesized SRS concept requirements and an example of the scenario adopted to present re-quirements to participants through possible realistic usage situations.

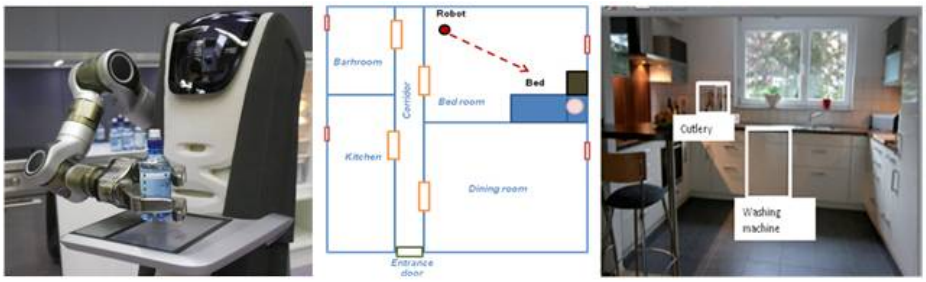

Fig. 1. Examples of images presented to participants: left, the current robotic platform care-o-bot 3 in use in the project (Graf B. t al., 2009) developed by Fraunhofer Institute for Manufacturing Engineering and Automation; center, the possible way to control the robot by navigating it from a remote position using a map of the elderly's apartment; right, the robot ability to recognized already learnt objects.

Table 1. From user requirements to concept requirements: an extract of usage scenario derived from user requirements survey.

User requirements from first user's survey results	SRS concept requirements, defined from user requirements
• Emergency managing • Fetching and bringing objects Help in standing up • Help in cooking • Low interaction with technology for elderly • Concern for the home environment • Monitoring health of the elderly • Be able to give help at distance • Lowering family assistance charge • Assuring intervention in every case, • Considering privacy and ethics	• Simple and wearable personal device (few large buttons to send an SRS request to a remote operator or to start autonomous robot functions). • Robot Accurate and safe manipulation of objects • SRS on a mobile platform and Autonomous identification of obstacles • Robot' Autonomous functions execution • Portable and ready to use device to tele-operate the robot: navigation through the map of the house, easy teaching of new objects and new procedures to the robot. • Robot automatic recognition of already learned objects and procedures from a database • Call priority chain: first contacting family, then assistance centre. • Telecommunication option and authorization procedure for privacy protection • Professional SRS-workstation to control the robot executing particularly complex maneuvers (manual control of the robotic arm…)

User requirements from first user's survey results	SRS concept requirements, defined from user requirements
Scenario example- translation of concept requirements into a realistic usage situation	
Elisabeth Baker , 84 years old, widow, suffers from high blood pressure; this morning she wakes up and she feels so dizzy that she can't get up to reach the medicine she has to take. She decides to call for the help of the SRS robot using her personal device that she always carries with her. She is not confident with technology so she just sends a call to a remote operator. *The woman's request is sent to her son: The son is at work but seeing a request from the mother on his SRS-portable device starts a remote session from his workplace. So communication is established and he can immediately send the robot to the kitchen ,to take the medicine and a glass of water, then brining them to her mother…*	

2.3 Quantitative and qualitative questionnaire

A tailored version of quantitative and qualitative questionnaire based on a Likert type scale [1 to 5 range scale, where 5 is the highest degree of acceptance] was developed for each different interviewed group. The questionnaire consisted of 16 to 20 items (depending on the interviewed group) regarding in particular the utility and acceptability of the robot for the particular tasks presented; the acceptance by the proposed people involved in the remote robot control; the possible human-robot interaction devices and interaction modalities and the overall appearance of the robot. After quantitative answers, "why questions" were complementarily presented in order to gather qualitative information for understanding reasons behind a particular rating.

3 Results

3.1 Scenarios approval

The most popular robotic scenarios were those linked to safety. A robotic solution for monitoring and managing the emergency was very well accepted, mostly for intervention in case of emergency, but also just for monitoring the situation at all times. The idea of the robot putting in contact the injured old person and the relative when an emergency happens, providing immediate psychological support and health status information to the remote operator has been considered a good idea by all of the interviewed groups.

A robotic solution for standing-up assistance was quite well accepted. However, one of the most meaningful old person's statement looking at the presented scenario was: "*I wish I had something to help me getting up by myself but I wouldn't have enough force to stand up from the ground just grabbing the handle of the robot...the presented solution could be dangerous for me*". This statement reflects a common conviction shared by all the interviewed people. Most of them liked the idea, but at the same time they have too many concerns about the technical implementation of the robot. Health professionals, experts in Assistive Technologies, especially underlined how difficult it could be for an old person to get up after a fall and so just how dedicated an assistive device of this kind would have to be in order to be effective and safe. So they think that this function should be better implemented into an assistive

technology designed just for that purpose and not as one of the functionalities of a service robot.

A robotic solution for help in fetching and carrying was quite well accepted, most of all by family members and 24 hours call centre personnel, who consider this robotic function as the more "*feasible*". Health professionals instead, suggested that the "remotely operated fetching objects function" could better represent an interesting potential solution for visually impaired people, and wheelchair bound people of any age.

Finally, the robotic solution for preparing food was not well accepted. Figure 2 shows some extracts of visual simulations used to explain scenarios and mean results and standard errors obtained from the questionnaire section about requirements related to robotic tasks usefulness.

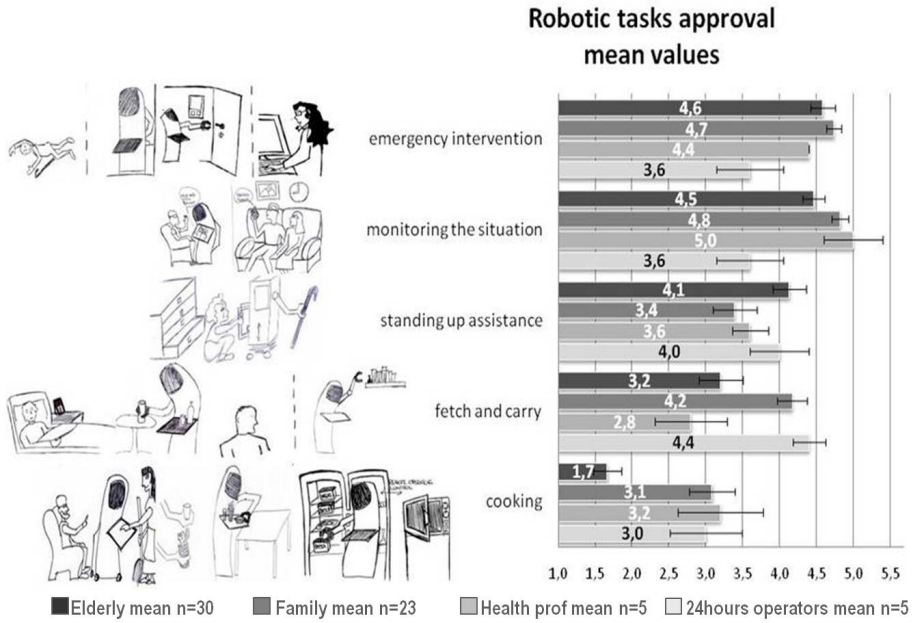

Fig. 2. Approval of the robotic help for the particular task presented [1 to five scale, where 5 is the highest degree of acceptance]. The graph reports mean values and standard error bars of the four groups: 30 frail elderly people, 23 family members, 5 geriatric health professionals and 5 tele-operators. Results are showed using the elderly mean rating scale.

3.2 Remote operators and local operators

Results about the involvement of other possible operators of the SRS system in addition to family members showed the acceptance of an always available external call centre service. Elderly people however, would prefer the help of their relatives or informal caregiver who usually cares for them. However they are not against the idea of a 24 hour service always available, because they are well aware that their relatives could be not available at the time an emergency happens, so a 24 hour service could

be very useful, but it should be considered the last option, just in case of relatives' unavailability.

The 24 hour call centre operators interviewed are used to technology. They are often trained as nurses, doctor's assistant or case manager and typically female. They are familiar with a variety of different computer programs and often work with multi-screen setups. Also they are knowledgeable about many different devices used by the elderly (e.g. various types of emergency button systems from various brands, GPS-localization devices, etc.). They are already involved into services that offer help to the elderly and they stated that SRS would be a useful addition; they mentioned for example that it would be helpful to see an elderly person in an emergency situation to assess the severity of the situation (*e.g. "bleeding?, lying on the floor?, epileptic attack?"*). Quantitative results about approval of the introduction of a tele-assistance service are expressed in figure 3.

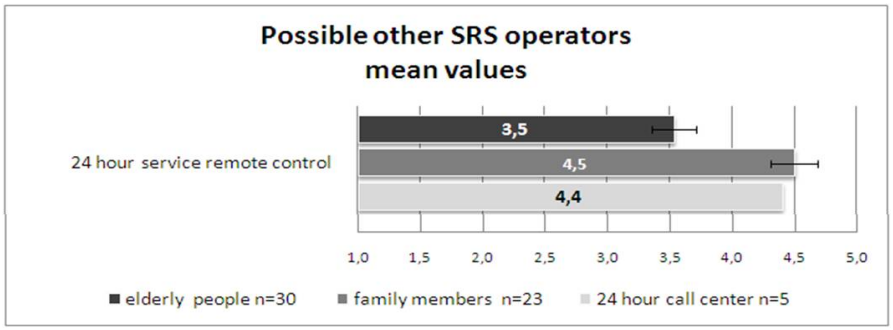

Fig. 3. Approval of the idea of a 24 hour telecare operator as SRS operator. [1 to five scale, where 5 is the highest degree of acceptance]. The graph reports mean values and standard error bars of three groups: 30 frail elderly people, 23 family members, and 5 tele operators at 24 hour call center.

3.3 Human-robot interfaces and interaction modalities

The elderly liked the idea of using a simple wearable device (mean questionnaire value: 4,6) to control the robot, to contact a remote operator, or to make an emergency call. This is because some of them have already had some experience with wearable alarms or reported cases of other elderly friends who use them.

Most of them also liked the idea of the video call (mean questionnaire value: 3,6), stating that looking at their relatives in the face while talking, could be calming and reassuring or useful in case of an emergency call, to judge the severity of the situation and the eventual need for an intervention.

The 24 hours call center workers however expressed some concerns regarding privacy issues, stating that the elderly may not like the idea of being observed by strangers. However, only a few of the interviewed elderly confirmed these concerns about privacy, mainly because they consider more relevant the need of being in contact with someone that is supposed to help them.

Relatives and the staff of the 24 hour call center were mostly convinced about being able to act as remote operators. Most of them can imagine themselves using some

kind of system to remotely control the robot, to teach it how to recognize new objects, and to program the robot so as to execute certain tasks at set times. However family participants would prefer a portable device (mean questionnaire value: 4.6) and expressed some doubts related to how demanding teaching operations could be.

4 Discussion

The overall acceptance of a semi-autonomous, tele-operated, and learning robotic system with the aim to prolong independent living at home was fairly high among all user groups. One of the interviewed stated "I would feel safer having a robot like this at home always with me". This statement is emblematic, because it underlines the main relatives/caregivers' problem of being always available. Even if health professionals mainly stated that human help and contact is better than robotic support, they also recognized that too often the elderly are alone at home and their relatives cannot offer immediate help, causing also potential risks for the elderly individuals. Relatives and health professionals interviewed stated that elderly people "want to act right at that moment, without waiting for help" thus exposing themselves to a risk, because sometimes not aware of their limits. Providing them with a robotic system helping to reach some of their goals without having to wait for someone else doing it for them, actually would allow a safer and more independent condition.

Table 2 summarizes quantitative (presented by the overall mean and standard deviations values of all the interviewed groups) and qualitative results presented in the previous paragraphs about the importance of the tasks the robot should be able to perform. Final validation of the concept expressed in each scenario was considered reached if only light grey couples of quantitative and qualitative results were achieved.

Table 2. Robot usefulness documented in quantitative results (overall mean and standard deviations) and qualitative results. About quantitative results, the light grey color is used when the mean values (rating scale from 1 to 5) is over score 3,5 and dark grey if less then score 3,5. About qualitative results, the light grey background is used when results are mainly positive, and dark grey when they are mainly negative.

Robotic tasks overall approval (Elderly people, Relatives, Health professionals; 24 h service staff)	**Quantitative results** (mean. n = 63)	**Qualitative results** "Why questions"
Monitoring the situation	4,6 (0,81)	Providing health status information to the remote operator
Emergency intervention	4,5 (0,80)	Immediate psychological support
Standing up assistance	3,8 (1,29)	Safety concerns arising both for elderly and health professionals
Fetch and carry	3,6 (1,40)	Helping with heavy objects (>1kg) and objects placed too high. Exploitation for other target people possible also.
Preparing food	2,4 (1,43)	Cooking considered an important social function/hobby. Just "heating food in the microwave" considered useless function

Overall results demonstrated also that to support the scenarios and operation modes, along with requirements such as mobility of the elderly and their family, the interaction concept should foresee different interaction devices and modalities for each user group [2]. Feedback from user needs assessment, as well as the analysis of SRS usage scenarios clearly showed the need of a relatively small and mobile "all in one" interaction device for the elderly user and for informal caregivers. However, the professional user works in an office on a fixed workstation in the framework of a 24hrs service center and thus does not need to be mobile. For this last user interface, focus is on maximum of functionality and remote support as the last instance in the support chain. Results provided a clear and shared definition of the SRS concept (figure 4), providing technologists with enough information to proceed with the development phase.

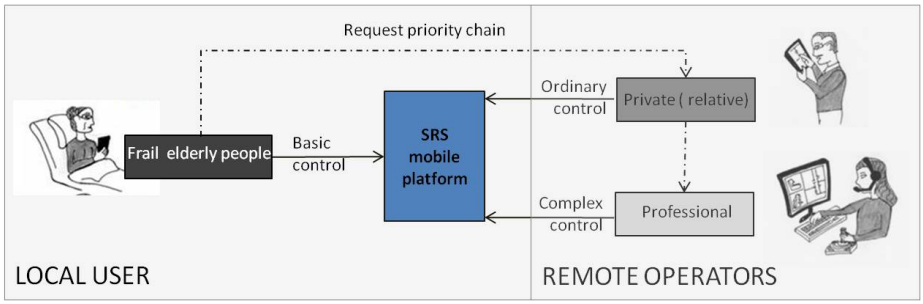

Fig. 4. The developed concept of SRS [2]. The figure shows the users of the systems, the idea of three different devices with increasing complexity that they should use to interact with the robot or with the other stakeholders, and the priority chain of intervention.

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