SEMI-AUTONOMOUS TELEOPERATED LEARNING IN-HOME SERVICE ROBOTS FOR ELDERLY CARE:
A QUALITATIVE STUDY ON NEEDS AND PERCEPTIONS OF ELDERLY PEOPLE, FAMILY CAREGIVERS, AND PROFESSIONAL CAREGIVERS

Marcus Mast, Michael Burmester, Eva Berner
Stuttgart Media University, Germany, {mast, burmester, eb019}@hdm-stuttgart.de

David Facal
Fundación Instituto Gerontológico Matia - INGEMA, Spain, david.facal@ingema.es

Lucia Pigini
Fondazione Don Carlo Gnocchi Onlus, Italy, lpigini@dongnocchi.it

Lorenzo Blasi
Hewlett-Packard Italiana S.r.l, lorenzo.blasi@hp.com

Abstract: This paper reports the results of a user requirement study for a robotic system aiming to support independent living of the elderly. A concept is investigated where caregivers would teleoperate and teach a domestic service robot on tasks it currently cannot perform autonomously. Focus groups were carried out in three European countries with 59 participants. Results show a preference for emergency and household functions among elderly and caregivers. However, most professional caregivers stated to prefer personal contact to the assisted person and opposed the prospect of being a teleoperator. Some family caregivers welcomed teleoperation because it would free them from being bound to the elderly's home; others showed reservations, mainly due to concerns of having even less time for themselves. Implications for the design of a robotic system are discussed.

Keywords: Service Robot, Teleoperation, Learning, Elderly, Caregiver, User Requirements

1. Introduction

With aging populations, many developed countries in Europe and worldwide are facing a situation where fewer young people have to support an increasing number of old people. Japan, Italy, Germany, Sweden, and Bulgaria currently show the highest percentages of population aged 60 or over in the world (ranging from 29.7% for Japan to 24.2% for Bulgaria) [1]. In the European Union, in 2008, 100 persons of working age (15 to 64 years) supported 25 persons aged 65 or over. In 2030, 100 persons are expected to support 38 persons [2]. This trend is reflected worldwide with 100 working age persons supporting 11 persons aged 65 or over in 2009 and a projected 25 in 2050 [1].

Personal service robots could be an interesting option for addressing the resulting bottleneck in the healthcare system, supporting elderly people's independent living and aging in place.

However, the heterogeneous and unstructured domestic environment still poses substantial technological challenges for robots in many areas of artificial intelligence such as decision making, 3D environment perception, object recognition, classification, or safe manipulation [3], hindering a rapid deployment of service robots to end user environments.

To address this problem, the research project "Multi-Role Shadow Robotic System for Independent Living" (SRS) aims to supplement robotic intelligence with human intelligence. When the robot encounters an unknown situation it cannot handle autonomously, a teleoperator is contacted. Through automated learning from the teleoperation and active teaching, human involvement is intended to decrease over time, the robot's functional range extended, and its behavior adapted to the local context.

When designing a robotic system, the most urgent needs of the prospective users and the tasks that users would accept help with from a

robot should be prioritized. A semi-autonomous, teleoperated, and learning robotic system in the field of elderly care could potentially involve the following user groups: (1) elderly persons, (2) relatives providing care (typically the elderly's children), and (3) professional caregivers. The study presented in this paper investigates the needs and perceptions of these user groups.

2. Related Work

A number of studies have investigated user needs and perceptions for service robots. An early study by Khan [4] on the perceptions of adult but not specifically elderly users (20 to 60 years) with regard to domestic service robots showed a positive general attitude and openness to the concept of robotic assistance in the home. Most participants preferred a small size of the robot due to space restrictions in the home, verbal communication, robot movement at walking speed or slower, a machine-like appearance as opposed to a humanoid appearance, and they did not perceive a robot as a privacy intrusion. There was a tendency for participants to prefer a robot that strictly follows programmed procedures over one that would make independent decisions, indicating a need for predictability and control. Participants wished help by a robot most often with the following tasks: cleaning windows, cleaning ceilings and walls, cleaning, wetcleaning, moving heavy things, and wiping surfaces clean. Baby sitting, watching dog/cat, and reading aloud were the least desired tasks.

The preference for functional household work like window cleaning, laundry, or vacuuming with a tendency for rejection of interactive and social tasks was confirmed in subsequent studies on general user perceptions by Dautenhahn et al. [5] and Ray et al. [6] along with most other findings like moderate speed of movement, predictability of the robot's actions, and human-like communication but not appearance.

Derpmann and Compagna [7] carried out a requirements analysis for service robots in an eldercare facility, involving elderly, professional caregivers, and care management. They note that the elderly in this context largely rejected the idea of a service robot, fearing that a robot could never meet the complex task requirements, that the technology might malfunction, and that it might lead to a decrease in human social contact. Caregivers often associated the introduction of a robot with the loss of their job. This was also found by Ray et al. [6] who remark that "the re-

placement of people by robots, in particular in their job, is perceived as a problem."

Boissy et al. [8] focused on the requirements of health professionals (e.g. department heads of care hospitals, physicians) and elderly people (68 to 92 years) for home telecare. Participants suggested various telecare functions like remotely monitoring loss of autonomy, ensuring safety when patients leave hospital, virtual doctor visits, and telesurveillance so the family caregiver can leave the house. Most of the suggested functions were emergency and monitoring functions. General household tasks were not within the scope of the study. Both elderly people and health professionals were concerned about privacy in view of the cameras needed for telepresence. Elderly mentioned that if a telepresence system became necessary, a nursing home would seem more pertinent. As in the previously mentioned studies, there were concerns on the robot's size and on the substitution of social contact.

Faucounau et al. [9] surveyed informal caregivers (mainly relatives) on domestic assistive robots for elderly care. The most desired functions were cognitive stimulation, fall detection, detection of inability to get up after a fall, help calls, abnormal positions detection, drug intake reminder, and communication with health professionals. Frequent caregiver needs were to have more time for themselves, more time for activities with the elderly person, and to get support caring for the elderly person. In case of an emergency, the caregivers thought that teleoperation by a professional would be useful. In agreement with [4] but contrary to [8] and other studies [e.g. 10], caregivers had no privacy concerns in view of the cameras on a teleoperated robot. A possible reason for the different results could be differing perceptions of privacy intrusion between cultures, as found in [11].

Contrary to common belief and to some studies [7, 8, 12], Ezer et al. [13] found that older adults (65 and over) were not less willing to have a robot in their home than younger adults. There were even more elderly than younger adults who thought of safeguarding functions as useful. Again, the preference for non-interactive household tasks was confirmed.

Overall these studies have shown that there is a positive attitude towards robots in the home but people have concrete expectations for the size, look, communication style, and functionalities of a service robot. There seems to be a preference for safeguarding and emergency functions and for monotonous household tasks, and an aversion

to social, interactive functions. Some findings are contradictory, like the perception of privacy intrusion or the acceptance by elderly. None of the studies investigated user requirements for a teleoperated domestic elderly care robot with all possible user groups and considering the complete range of possible functionalities.

3. Research Questions

We were interested in how the potential user groups (elderly people, family caregivers, and professional caregivers) of a prospective semi-autonomous, teleoperated, learning service robot for elderly care would perceive such a system and what their needs and difficulties are. Guiding questions were:

- What are the difficulties of elderly people still living at home and of caregivers?

- What is the users' attitude toward the concept of a semi-autonomous, partially remotely controlled, and learning robot?

- Which functions would users desire and reject in such a robot? How do they think about social, interactive functions?

- What is the perception of the teleoperation functionality? Are there privacy concerns?

4. Method

The focus group method of user-centered design was applied [14, 15]. Focus groups are moderated and structured group interviews on a specific subject where interaction and discussion between participants is encouraged. They generate qualitative data and are particularly suited for requirements engineering. Focus groups provide information on the attitudes, desires, and priorities of the target audience and on the "why" and "how" behind them.

Participants

In total, 59 persons participated in the study. Focus groups were carried out in three countries (Germany, Spain, Italy) for a higher validity of results although cultural differences were not of primary interest. During recruitment, a "technology project to assist elderly" was mentioned but no reference to robots was given.

22 elderly persons (77% female) with a mean age of 80 years (65 to 90) participated in 4 focus groups in all three countries. They still lived at home but had some difficulties with the activities of daily living (e.g., due to mobility problems or hearing) and most received some form of assistance because of that. Participants had no severe disabilities (e.g. dementia, complete loss of hearing, bedridden).

17 family caregivers (88% female) with a mean age of 55 years (46 to 64) participated in 3 focus groups in Germany and Spain. Family caregivers received no payment for their care. Most (60%) cared for their parent but some for grandparents, mother-in-law, or aunt.

20 professional caregivers (80% female) with a mean age of 46 years (30 to 61) participated in 4 focus groups in all three countries. Participants were trained professionals (e.g. geriatric nurses, social pedagogues) working for mobile care services (visiting different elderly in their homes each day), permanently for a single elderly person in the home, or in assisted living facilities.

Procedure

The focus groups were carried out with an interview guide in two phases. After an introduction and the signing of the informed consent, participants were first interviewed on their difficulties in the care situation, regardless of technology considerations. In the second phase, the concept of a semi-autonomous robot that could learn from continued usage and teaching and be teleoperated was introduced. 15 robot application scenarios from a wide range like emergency, household, and emotional support were explicated with videos of existing robots and illustrations of the robot in action. Participants also had the opportunity to suggest their own applications. After each scenario first open and then more specific questions were asked about the participants' perceptions. Special consideration was given to the teleoperation aspect. An example of an illustration for teleoperation is shown in Figure 1.

At the end of each phase, participants prioritized needs and applications by placing sticky dots on a flipchart with the topics discussed. All participants were interviewed on their own needs and perceptions and caregivers additionally on the assumed needs and perceptions of the elderly persons in their surrounding. The duration of the focus groups was between 1.5 and 3 hours.

Data analysis

Transcripts of the focus group sessions were decomposed into text segments of participant statements. The segments were summarized and

then rearranged and grouped across participants to inductively derive common themes.
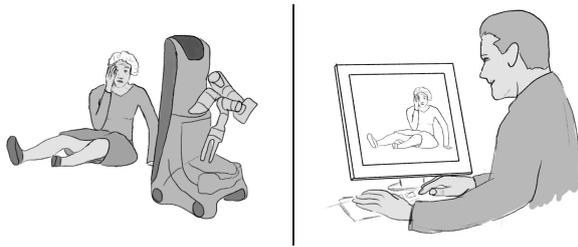
Figure 1: Illustration presented to participants to explain teleoperation after a fall

5. Results

Results are subsequently reported commonly for the three countries. Substantial deviations between countries are noted where applicable.

Participants' difficulties

The difficulties of *elderly people* can be assigned to three categories: psychological difficulties, health problems, and difficult tasks. Highly prioritized psychological difficulties were loneliness due to decrease of social relationships (this was an important issue for some participants but not for others), lack of autonomy (dependence on caregivers and often associated paternalism), and fear of falling. The most highly prioritized health problems were a decrease in overall energy (muscle strength, endurance, speed – often mentioned in connection with cleaning work), decreased hearing ability and eyesight (especially reading small letters on instruction leaflets or food packages), and forgetfulness (e.g. regarding taking medicine). Prioritized difficulties with activities of daily living were mobility-related ones (climbing stairs, shopping, climbing bath tub, reaching objects), housework (cleaning windows, vacuuming, cleaning bathroom and toilet, changing curtains, carrying water), preparing food, shopping (especially carrying heavy shopping bags), putting on clothes (pants, shoes), operating electronic devices, and official affairs (financial, insurances, etc.).

Family caregivers stated that they do not primarily have difficulties with particular activities like shopping or cleaning. Rather, their difficulties are of a psychological or emotional nature. Participants often mentioned the burden of having to be constantly present and reachable by the elderly person and also difficulties in coping with the elderly person's expectations or a fear of not meeting them (e.g. caregivers are often afraid they did not help sufficiently). Caregivers further stated that they often felt that they were being overly consumed by caregiving. Regarding specific activities, providing intimate care (e.g. body care) and helping with official affairs (e.g. financial) were most often considered unpleasant.

Those *professional caregivers* who cared permanently for a single elderly person, often living in the house of the assisted person, tended to mention psychological issues similar to those mentioned by the family caregivers (e.g. being overly consumed). They emphasized continuous stress, e.g. because of having to be alert at night or worrying when going outside for shopping, leaving the assisted person unattended. Moreover a lack of trust from both the assisted and the family of the assisted person was mentioned. Psychological factors instead were not as prevailing for professionals who cared for a number of elderly as part of a service or in an assisted living facility. They showed less emotional involvement and seemed to maintain a professional distance. Regarding specific activities, foremost they mentioned bureaucracy (e.g. documentation of care) as unpleasant. Lifting and transfer of elderly persons was also regarded demanding by many participants. It was stated that professional caregivers often have back problems due to the heavy lifting. Other issues rated important were: fast pace of their work, in particular leading to a lack of time to provide emotional support and conversations, bad smells in the apartment of the elderly people, and disputes with physicians regarding appropriate measures and treatment of patients.

Perception of the concept of a semi-autonomous teleoperated learning robot in the home

In Germany and Spain, the overall acceptance of a semi-autonomous, teleoperated, and learning robotic system in the home was fairly high across all user groups. Still, in some groups there were one or two opposers. The general purpose of the system to prolong independent living in the home appealed to participants. Participants mentioned the advantage that an all-purpose robot could replace many specialized devices (e.g. lifter, emergency system). Most concerns in Germany and Spain came from professional caregivers who were often concerned about "replacement of human contact", loss of their job, or that a robot may lead to physical and mental inactivity of the elderly person. Caregivers often assumed elderly acceptance to be low but this was

not the case for most German and Spanish elderly participants.

Participants in Italy were more reluctant overall to embrace the idea of a robot in the home. While they favored certain functions over others (largely in line with German and Spanish preferences, see next section), the majority of elderly and many caregivers rejected robotic assistance altogether. Rejection was on the same grounds as in German and Spanish groups, i.e. replacement of human contact, supporting inactivity, etc. Some bias might have been present because a general technology-centered topic was mentioned during recruitment.

Regarding teleoperation and learning it generally appealed to participants that a robot's range of functions could be extended by such means. However, altogether results on this aspect were mixed. Elderly in Italy were suspicious about teleoperation, questioning the advantage of telecare over local care. In contrast, in Germany and Spain, elderly acceptance was high - the highest among the three target groups - presumably because the elderly would be the main beneficiaries of such a concept. Objections were raised in all countries by caregivers on their advantages as teleoperators. The idea of being a teleoperator was rejected by many professional caregivers, most strongly in Germany, stating e.g. "If I had to work like that, I would quit my job". Spanish professional caregivers were more open to the idea. However, in all three countries professional caregivers stated that they prefer to work with people in direct contact. Among family caregivers there was no clear consensus. Some sympathized with the idea, stating e.g. "It's great to be able to leave the house while knowing I can still be there". Others objected that such a system may increase their burden of constant availability, fearing e.g. that the elderly person may then even call them when they are on vacation, effectively leading to a 24h/365 day availability. It was also mentioned that family caregivers usually work during the week and would not have time to answer a teleoperation request. When we outlined the possibility of a dedicated professional teleoperation service, this was usually met with approval by the participants of all target groups.

Elderly and caregivers alike usually did not see any privacy threat initially. Only after we told them about the possibility of misuse (e.g. hackers causing physical harm by remote manipulation or privacy intrusion due to the robot's cameras), caregivers and younger participants often changed their mind. Interestingly, most (but not all) elderly still did not see a privacy threat even after we had told them about possible misuse, stating e.g. "there must be ways to make this secure". Most participants considered it essential that the elderly person would have to authorize each request for teleoperation.

Overall, the topic of teleoperation and learning was discussed controversially. In almost all focus groups, some participants advocated it, others rejected it, and yet others were indecisive.

Desired and rejected robot functions

There was good consistency between countries and between elderly and caregivers in which functions would be desirable and which would not be. The most highly prioritized ones were emergency-related (e.g. fall detection, making emergency calls). Other desired functions were: reminder functions (e.g. for appointments, medications), fetch and carry services (e.g. book from high on shelf), mobility assistance (e.g. help get up from chair, bed), playing board games with a friend at a remote site, video conferencing, cleaning windows, vacuum cleaning, and washing clothes. In Germany only, a few elderly participants also rated emotional support highly (e.g. hugging) and conversations with a robot to address the issue of loneliness. However, overall, socially interactive functions like conversations or emotional support and functions related to personal hygiene like bathing were rejected most often. Emergency functions and household work like cleaning or cooking had the fewest opposers.

Other desired characteristics of the service robot were: a friendly appearance, human voice, ability to switch the robot off, easy to use (preferably voice commands), slow or moderate movement and manipulation, and a small size.

6. Discussion

Many results of the present study are in agreement with previous studies such as acceptable and rejected functions [4, 8, 6, 5, 9, 13] or the preferable size of the robot [4, 6, 8]. Across all user groups and countries, emergency functions and household functions were most often desired by participants while social and body care functions were most often rejected.

The distinctive characteristic of the present study was its focus on teleoperation and learning and the associated inclusion of three different user groups: elderly people, family caregivers, and professional caregivers. There have not been

many studies on caregivers' requirements for service robots [9]. Our findings show that while the elderly often have difficulties with certain activities (e.g. climbing the bath tub), for family caregivers psychological factors are much more prevalent due to the close emotional ties with the elderly person. This finding is in agreement with [9]. Professional caregivers instead show much more emotional distance and their difficulties are more related to the high workload having to care for many elderly in little time (e.g. leading to back problems due to lifting and transfer) and the high administrative overhead involved in care.

Perhaps the most unexpected finding is that there was substantial opposition by professional caregivers and to some extent also by family caregivers to the prospect of teaching and tele-operating a domestic service robot by themselves. Professional caregivers overall seem to be an unsuitable target group for teleoperation due to their refusal to engage in care via technology and their perception of the robot as a "competitor" for their job [cf. 6, 7].

The psychological burden and time restrictions of family caregivers who usually work during the week should also be considered. An option to address this could be to employ a 24-hour professional service center for teleoperation, perhaps as the last instance in a call priority chain first contacting family caregivers. Another measure could be to design a highly engaging user experience so teleoperation and teaching would become an enjoyable activity for the users. Family caregivers may have an incorrect image of how the teleoperation and teaching functionality would work.

Some indication for cultural differences was found: for example Italian participants were more rejecting towards several aspects of a robot in the home. Cortellessa et al. [11] mention differences in national elderly care culture and in technology uptake as possible reasons. However, given the nature of a qualitative study, such differences would have to be verified by further studies.

Acknowledgement

References

[1] United Nations, "World Population Ageing 2009", New York: United Nations Department of Economic and Social Affairs, 2009.

[2] K. Giannakouris, "Regional Population Projections EUROPOP2008: Most EU Regions Face Older Population Profile in 2030", Eurostat, 2010.

[3] V. Kumar, G. Bekey, and Y. Zheng, "Industrial, Personal, and Service Robots" in *International Assessment of Research on Development in Robotics,* G. Bekey et al., Eds. Baltimore: WTEC, 2006, pp. 55-62.

[4] Z. Khan, "Attitudes towards intelligent service robots", Stockholm: Royal Inst. of Technology, 1998.

[5] K. Dautenhahn, S. Woods, C. Kaouri, M.L. Walters, K.L. Koay, and I. Werry, "What is a Robot Companion – Friend, Assistant or Butler?", in *Proc. IEEE/RSJ International Conference on Intelligent Robots and Systems,* 2005, pp. 1192-1197.

[6] C. Ray, F. Mondada, and R. Siegwart, "What do people expect from robots?", in *Proc. IEEE/RSJ International Conference on Intelligent Robots and Systems,* 2008, pp. 3816-3821.

[7] S. Derpmann and D. Compagna, "Erste Befunde der Bedarfsanalyse für eine partizipative Technikentwicklung im Bereich stationärer Pflegeeinrichtungen", in D. Compagna and K.A. Shire, (Eds.), *Working Papers kultur- und techniksoziologische Studien,* 5, 2009.

[8] P. Boissy, H. Corriveau, F. Michaud, D. Labonté, and M. Royer, "A qualitative study of in-home robotic telepresence for home care of community-living elderly subjects", *Journ. of Telemedicine and Telecare,* vol. 13, 2007, pp. 79-84.

[9] V. Faucounau, Y. Wu, M. Boulay, M. Maestrutti, A. Rigaud, and the QuoVADis project, "Caregivers' requirements for in-home robotic agent for supporting community-living elderly subjects with cognitive impairment", *Technology and Health Care,* vol. 17, 2009, pp. 33-40.

[10] G. Demiris, B.K. Hensel, M. Skubic, and M. Hantz, "Senior residents' perceived need of and preferences for 'smart home' sensor technologies", *International Journal of Technology Assessment in Health Care,* vol. 24, 2008, pp. 120-124.

[11] G. Cortellessa, M. Scopelliti, L. Tiberio, G.K. Svedberg, A. Loutfi, F. Pecora, "A Cross-Cultural Evaluation of Domestic Assistive Robots", in *Proc. AAAI Fall Symposium on AI in Eldercare, Washington, DC, USA,* 2008, pp. 24-31.

[12] M. Scopelliti, M.V. Giuliani, and F. Fornara, "Robots in a domestic setting: a psychological approach", *Universal Access in the Information Society,* vol. 4, 2005, pp. 146-155.

[13] N. Ezer, A.D. Fisk, and W.A. Rogers, "More than a Servant: Self-Reported Willingness of Younger and Older Adults to having a Robot perform Interactive and Critical Tasks in the Home", in *Proc. Human Factors and Ergonomics Society 53rd Annual Meeting,* 2009, pp. 136-140.

[14] S. Caplan, "Using focus groups methodology for ergonomic design", *Ergonomics,* vol. 33, 1990, pp. 527-533.

[15] M. Kuniavsky, *Observing the User Experience: A Practitioner's Guide to User Research.* San Francisco: Morgan Kaufmann, 2003.