Practical Evaluation of Service Robots for Support and Routine Tasks in an Elderly Care Facility

Theo Jacobs, Birgit Graf, *Fraunhofer IPA*

***Abstract*— By taking over dull routine tasks, service robots can provide the personnel of residential care facilities with additional time for their actual care tasks. Together with the employees of an elderly care facility, possible areas to support care workers have been identified and support scenarios have been developed as part of the project WiMi-Care. On the autonomous transport vehicle CASERO and the household assistant Care-O-bot® 3, four scenarios were implemented and tested during two practical evaluations.**

I. Introduction

In the next 40 years, the ratio between elderly people and gainfully employed people will change dramatically [1]. One result will be that a limited number of care workers will have to care for an increasing number of elderly people. A way to ease this situation is to apply service robots in elderly care facilities to take over repetitive and demanding routine tasks. Care workers are thus given more time for interacting with the inhabitants and the quality of care work is ensured.

The goal of the WiMi-Care project (www.wimi-care.de) was to identify the need for support by service robots and to identify possible scenarios in a close dialogue with the employees of a care facility. Selected scenarios were then implemented on two existing service robot systems and tested in two practical evaluations. During each test the feedback from inhabitants and employees was carefully evaluated with the aim to create a knowledge transfer loop between designers and users of the robots.

II. Involved Service Robots

For the implementation and testing of support tasks in elderly care facilities, in WiMi-Care, two different service robots were involved: CASERO, an autonomous transport vehicle developed by MLR System GmbH (www.mlr.de, Fig. 1) and the robotic home assistant Care-O-bot® 3, developed at Fraunhofer IPA (www.care-o-bot.de, Fig. 2).

CASERO is based on existing products that are well-tested in practical applications such as transport tasks in hospitals and libraries. The robot is able to pick up containers and to deliver goods inside a building. Its navigation system enables the robot to autonomously follow predetermined routes to its destination and stops the robot when an obstacle blocks its path.

Manuscript received December 31, 2011. Part of this work has been supported by the WiMi-Care project funded by the German Federal Ministry for Education and Research (FKZ: 01FC08024-27)

Dip.-Ing. Theo Jacobs and Dr.-Ing. Dipl.-Inf. Birgit Graf are with the Fraunhofer IPA, 70569 Stuttgart, Germany (+49-711-970-1339/ 1910; fax: +49-711-970-1008; e-mail: theo.jacobs / birgit.graf@ipa.fraunhofer.de)

Fig. 1. Autonomous transport vehicle CASERO

Care-O-bot® 3 is the product vision of a robotic home assistant which can help people in their daily lives [2][3]. It is able to perform basic tasks in the household such as fetching and bringing objects. In addition to its mobile base it is equipped with a robot arm and a camera system to localize and grasp objects. It also has a tray which is used for user interaction. An important aspect of Care-O-bot® 3 is the functional, product-like design allowing practical tests with end users. The robot has further been given a functional design, outlining its abilities as a butler. By avoiding a humanoid shape, the expectations of the users are focuses on the actual capabilities of the robot.

Fig. 2. Robotic home assistant Care-O-bot® 3

III. Requirements Analysis in an Elderly Care Facility

In order to identify the demand of the care workers for support, several open-ended interviews with the employees of the elderly care facility were conducted. This included members of the management as well as care workers in direct contact with the inhabitants. In addition, for the duration of a week, care workers were accompanied during day and night shifts in order to understand what tasks they are confronted with in their daily work. The requirement analysis showed that care workers would like to have support in different fields, examples are

- Transport and logistics tasks
- Housekeeping tasks directly connected to the care work
- Additional demands from daily practice such as
  - Lifting persons out of bed or into the bath
  - Support during the night shift, especially when emergencies occur
  - Automatic documentation
- Additional demands to foster the independence of the inhabitants such as
  - Potation supply
  - Reminder functions
  - Intelligent communication devices

In a second step the identified demands were compared to the abilities of the two available robots, identifying those tasks that could be fulfilled during the project and on the other hand could not be solved with much easier and thus less expensive approaches. In the end, two scenarios were selected for each robot.

For CASERO, a transportation scenario was selected which included regular transports (e.g. bringing laundry to the basement, bringing meals to the ward, delivering post and medicine) as well as irregular deliveries (e.g. bringing and taking away single dishes and delivering urgent medicine). As a second scenario CASERO supported the night shift by patrolling the corridors to identify inhabitants that had left their rooms. Therefore the laser scanners of the robot were used for detection. In case of an emergency, for example when an inhabitant had fallen on the corridor, the robot supplied the care worker with first aid material and provided access to the inhabitant's medical documents.

The scenarios selected for Care-O-bot® 3 also involved direct interaction of the robot with the inhabitants. In a potation supply scenario the robot drew water from a water cooler, drove autonomously to sitting areas, identified present inhabitants with its camera system and offered it to persons who had not drunken enough fluid yet. When the drink was taken, the amount of fluid served to the person was documented in a central database together with amounts of fluid served and recorded manually by the care workers. In the entertainment scenario Care-O-bot® 3 offered mind training games such as memory on its tray but also offered to play music files in order to motivate the elderly people for singing.

The selected scenarios were presented to the employees of the care facility which were asked to give their opinion on the way the tasks were solved and to use their experience to identify possible problems. These presentations were repeated several times throughout the scenario development process.

IV. Practical Evaluations

In the project WiMi-Care, two practical evaluations of one week each were conducted to evaluate the identified support scenarios. The first practical evaluation, which was done after half of the project duration, focused on the technical feasibility. As at this time the scenarios were not fully implemented yet, only the potation supply and the transport scenario were tested in a simple form. This allowed the researchers to identify problems and to derive additional requirements for the further technical development of the robots.

In the second test phase which was held at the end of the project, all four scenarios were evaluated. During daytime CASERO was used to transport goods between a ward and the basement (Fig. 5). During the night shift the ability to patrol on corridors and to support in emergency situations was shown (Fig. 6).

Fig. 5. CASERO transporting a container with laundry to the basement

Fig. 6. CASERO having called a care worker after detecting an inhabitant on the corridor during night shift

Care-O-bot® 3 was used to deliver water from a water cooler to the inhabitants (Fig. 3). In addition the elderly people could play memory on the robot's tray (Fig. 4).

Fig. 3. Care-O-bot® 3 offering and serving a drink to an elderly woman

Fig. 4. An elderly woman playing memory on Care-O-bot® 3's tray supported by a care worker

A. *Organization of the second practical evaluation*

In the beginning of the second practical evaluation, the robots were set up in two different wards of the care facility. At the same time, in different seminars with a total duration of about 6 hours, the care workers were informed about how to operate each robot. To give the care workers an insight in the performance of the robots under real life conditions, tasks to be executed by the robots could be commanded and supervised by the care workers themselves.

After the tests open-ended interviews were conducted with the employees to hear their impressions regarding the quality of support and the acceptance of the robots and to give them the opportunity to ask questions. Care workers working with Care-O-bot® 3 were also asked to evaluate the interaction of the robot with the inhabitants. This was supported by a direct observation of the elderly people interacting with the robot by a team of two social scientists and two engineers. During the tests, field notes and photos were taken to document the results.

B. *Technical performance*

As an effect of using well-tested technologies for autonomous transport vehicles which are already in daily use, for CASERO, a high reliability could be reached. Due to the smooth and safe movement of the robot with constant velocity, the behavior of the robot was predictable allowing employees and inhabitants but also visitors to trust the behavior of the robot. Obstacle detection and the maintenance of safety distances also worked very well.

Care-O-bot® 3 was able to navigate safely on corridors while avoiding dynamic obstacles. Despite high requirements towards the precision of positioning, the robot was able to operate the small buttons of the cooler so that in most cases the cups could be filled and grasped. The main challenges while delivering the drinks was the identification of the elderly people under difficult lighting conditions using face detection and approaching them in a crowded sitting room with a lot of obstacles like chairs and parked walking aids. Nevertheless addressing the inhabitants and offering them drinks had very good results. In most cases the robot could persuade the elderly persons to take the water from the tray and drink it.

During the test phase three different inhabitants together with care workers tested the possibility to play memory on Care-O-bot® 3's tray. As this required only that the robot drove to a sitting area and waited until the game was finished, this also didn't cause any problems.

C. *User acceptance*

The overall reaction from the personnel as well as the inhabitants of the elderly care facility towards the robots was very positive. During the practical evaluation the situation was relaxed. Asked to describe her view of the robot in her own words, a care worker described the elderly people as "curious, similar to when a new inhabitant arrives on the ward". CASERO was considered to be very large but also to be very silent. Together with its calm and smooth motion, this allowed employees and inhabitants to trust the robot, and not to be afraid when meeting it in narrow corridors. Many inhabitants reacted very open and spontaneously. For example, some of them waved their hands when seeing CASERO. Other asked curiously, how the tests were going. Although some care workers had concerns that the robot could be too large to move in narrow corridors - and especially in lifts - together with humans, a high acceptance of CASERO could be reached.

The appearance of Care-O-bot® 3 was characterized by the care workers as "likable" and "like a servant" and with respect to its speech output and the ability to bow also as "polite". The inhabitants reacted to the robot positively and spontaneously, e.g. by clapping their hands when Care-O-bot® 3 bowed or by answering the robot when it spoke to them, asking for example, what kind of drinks it was going to offer them. Another indicator for the high acceptance was the willingness of the inhabitants to take water from the robot after it was offered and to drink the water afterwards.

Compared with the first practical evaluation, the number of persons drinking the water given to them by the robot increased significantly. One reason is the further development of the speech output which now included addressing inhabitants by their name as well as asking them for a second and third time in case they didn't take the drink immediately.

CONCLUSION AND OUTLOOK

The practical evaluation of the two robots CASERO and Care-O-bot® 3 showed that in the near future, service robots are suited to be applied for different routine tasks in care facilities. However, in order to reach this goal, depending on the task, further research and development is necessary.

By adapting existing industrial systems, transport vehicles like CASERO can be applied in care facilities to transport containers with goods such as laundry or meals as a replacement for manually handled carts. Tasks that require a close interaction between robot and the inhabitants - like the potation supply scenario or the entertainment scenario - require further research on the way to a product. Important steps are:

- Development of a task-specific robot hardware with a low complexity to simplify control of the system and to reduce costs, thus making the investment in a robot system more attractive for care facilities
- Increasing the robustness and fault-tolerance as well as the reliability of the service robot to prepare it for real-life applications
- Development of sustainable business models for application and maintenance of robot system with health insurance companies contributing to the costs

In order to enhance existing service robots for application in care facilities, more practical evaluations will be necessary. A special focus should be on long-term experiments which will allow a more detailed evaluation and adoption of service robots for their applications as well as the development and evaluation of services for application and maintenance.

REFERENCES

[1] Dorbritz, J., et al., *BEVÖLKERUNG Daten, Fakten, Trends zum demographischen Wandel in Deutschland*. Bundesinstitut für Bevölkerungsforschung, Wiesbaden, 2008

[2] Reiser, U., Parlitz, C., Klein, P., "Care-o-bot 3 - vision of a robot butler" in *Beyond Gray Droids: Domestic Robot Design for the 21st Century*, Cambridge, UK, 2009

[3] Reiser, U., et al., "Care-O-bot 3 - Creating a product vision for service robot applications by integrating design and technology" in *The 2009 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 1992–1997. St. Louis, USA 2009