Service Assistant to Support the Elderly with Mobility Issues

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***Abstract*—The Care-O-bot 4 was developed at Fraunhofer IPA as a general purpose mobile service robot. In a continuous effort of exploiting its modularity and potential, we decided to develop new robots with Care-O-bot 4 as a basis. This paper details the process of developing the possible design of such a robot. In this particular case, the robot is envisoned as a mobile companion which is able to help the elderly with their mobility in domestic environment.**

***Index Terms*—elderly care, mobile robot, service robot, hardware design, concept design**

I. Introduction

In the last few decades, according to the nursing homes and elderly-care facilities, the average age of newly admitted residents has been increasing. Presently, the average age for new residents has reached 85 years. It is a known fact that the elderly would like to stay at their own homes as long as possible. However, living at home without constant care and observation might carry a certain risk of unattended emergency, especially for those who live alone. One of the common risks for the elderly is falling due to their frailness and difficulty in walking. For such a reason, we decided to develop a mobile service robot which can assist the elderly mobility at home, thus elevates the risk of falling. The robot should also be able to observe the elderly in domestic settings to alert responsible people in case of an emergency.

In recent years, there have been several researches, concepts as well as products focused on the mobility-assisted application. They were developed to cater different age groups in different settings. For example, Ottobock's Xeno is an reconfigurable electrical wheelchair for immobile patients [1], iBOT [2] is another example of electrical wheelchair, which claims to be able to move up and down staircases. Beside wheelchairs, there are also electrical rollators available in the market, such as Triumph Mobility's Rollz Motion² [3] and eMovements' ello [4]. From the traditional wheelchairs and rollators, these products evolved and became smarter, more complex and now have more functionality in general. However, they mostly cater for outdoor activities, and do not have observing function.

On the other hand, there are also researches which focused on the monitoring aspect of elderly care. For instance, Mobina [5] is a mobile communication platform which can detect emergency situation and contact the responsible personnel.

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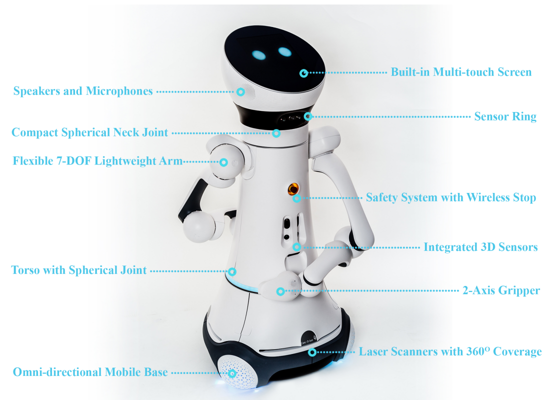

Fig. 1. Care-O-bot 4 developed by Fraunhofer IPA

Accompany project [6] is another example of using mobile service robot as a companion in domestic environment, where the robot, Care-O-bot 3 [7] in this particular case, can assume not only assistive but also preventive functions.

Contrary to the aforementioned products and researches, which either monitor or support the users, we envision the scenario where our robot could constantly monitor the well-being of the users, and assist their mobility only when they need it. In other words, we emphasize on letting the elderly to keep walking by themselves as much as possible, and the robot would always be by their sides and assist if necessary. Furthermore, we also place more importance into the observing capability of the robot, such that it can immediately response if incidents happen, especially in domestic settings, when the users are alone.

At Fraunhofer IPA, we had developed Care-O-bot 4 [8] (Fig. 1), a modular service mobile robot for general purpose. The base of the robot is a modular omni-directional mobile platform, which has 3 laser-scanners with 360° coverage. It also has its own computer with navigation and collision avoidance software modules integrated. As a continuous effort of exploiting the modularity of Care-O-bot 4, as well as expanding its applications in different scenarios, we intended to make use of its mobile platform as a basis, and adapt other parts to meet the requirements of this particular application of mobility assistance and monitoring.

II. Scenario

We created a persona, Agnes, to illustrate the application of our robot. Agnes is an 82 year old lady who is living independently in a small flat. She is mobile, but frail with a risk of falling so she has been given a walking frame; however, she rarely uses it inside the apartment. Lately, some critical situations have occurred where Agnes lost her balance and almost fell. Additional assistance to support her at home was obviously required.

Agnes decided to rent a robot companion to support her 24 hours a day. As the robot is with her all the time, it is able to work with her at her own pace. To assist her mobility, the robot moves with her around her flat, and she is able to steady herself by holding on to it, sit on it if necessary or put objects onto the robot to get them transported. The robot is also able to detect emergency situations and trigger an alert either for her daughter or an emergency center (e.g. if she does not emerge from the bathroom within a set period of time or she has fallen).

III. User Study

In order to verify the scenario, and identify the actual needs and opinions of the elderly on the robot, we conducted a pre-development user study at one of the assisted-living facility in Göppingen, Germany. We interviewed 7 residents (6 female and 1 male) in the facility:

- The ages of the residents vary, from 70 to 98 years old.
- They live in their own apartment (25-60 sqm), which are similar to their home environments. The care-staff only come once in a while if needed.
- All of them are using either walking cane or rollator indoor.

According to the result of the interviews, we summarized several important key points regarding the functionality of our robot:

- The elderly have little experience with smart-phone and touchscreen in general. They would prefer to control the robot either by voice or by hand gestures.
- They do not want an autonomous wheelchair-like vehicle but still want some robust assistance while walking.
- They do not mind having a camera constantly monitoring their activities. It must be noted that we had explained to them that the camera leaves no personal footprint, as it only track the skeleton model of the users.

Additionally, we also interviewed 7 care-staff at the facility. According to their feedback, we decided that the robot should also have a medication schedule reminder to reduce their workload.

IV. Conceptual Design

A. Functionality

We decided to narrow down the target age group for this application. The robot would focus on helping the elderly, who are frail and prone to falling, but still maintain some degree of mobility by themselves. And in order to meet the requirements from the users, the robot should have the following functions:

1) A mobile platform so that the robot can follow the user inside the apartment. As mentioned earlier, the base of Care-O-bot 4 will be used, since it is modular and integrated with necessary hardware and software for autonomous navigation and collision avoidance.
2) The upper part of the robot must have handle to support partially the weight of the users when they lean on it.
3) The robot should have a seat for the users in case of need.
4) The robot must have a tray for object transportation within the apartment.
5) The robot must have one (or more) camera to monitor users' activities in case of emergency.
6) The robot should have voice/gesture recognition system, or other modes of communication (e.g. remote controller) for human-robot interaction.

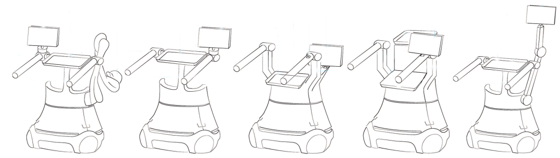

Fig. 2. Early concepts of the robot

Fig. 3. Mock-up model of the design for ergonomic study

B. Ergonomic Study

In order to determine the precise size and shape of the robot, we built a mock-up model of the robot with adjustable seat and handles, as shown in Fig. 3, then conducted an ergonomic study with 5 participants (4 female and 1 male). Based on the feedbacks from the participants, we have several conclusions:

- Rollator-like handles are not suitable as they need to be long to ensure a comfortable distance between the user and the robot. Furthermore, long handles leads to large footprint and stability issues for the robot.
- On the other hand, the handles should be on all sides of the robot so that the users can access them regardless of

Fig. 4. Illustration of the final design

orientations. The height of the handles should also be adjustable to accommodate the users varying in sizes. However, the adjustment only need to be done once manually at the beginning of the service.

- The precise height of the seat is not an important factor, as users only use it for a short period of time while resting.
- The tray on the robot should be large enough to standard object such as a dinner plate (260mm in diameter).

We also conducted a static study to determine the stability of the robot. In particular, it is important for the handle to withstand partially the weight of the users without destabilizing the base. With the assumption that the average weight of a user is approximately 80kg, we modified the handles in such a way that it covers the entire robot, as shown in Fig. 4 . By doing so, we could limit the situations where a user puts his entire body weight on the robot. Overall, the form factor of the robot is as follows:

- Seating area: 480mm of height with the size of 350 x 550mm.
- Handle: adjustable height from 650 to 800mm.
- Tray: fixed height of 900mm.

C. Final Design

Fig. 4 shows the illustration of our robot. The upper part of the robot was kept simple while still maintain high degree of affordance. By doing so, the users would be able to operate the robot intuitively without the need of complicated instructions.

The cameras, with pan & tilt mechanism, were kept within the housing of the robot to monitor the users' activities. While doing so would reduce the field of view of the cameras, it is the trade-off we made to lessen the uneasiness of the users having the cameras visibly tracking them constantly.

There is a push-to-open drawer at the back of the robot. When it is time for the users to take medication, the robot will remind them via speakers. The users can then open the drawer and take the medication by themselves. There is also a tablet which can instruct the user which medication to take according to her subscription.

Finally, Fig. 6 shows some of the different ways the robot could be used in everyday activities.

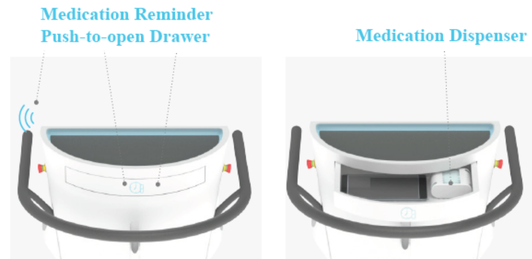

Fig. 5. Push-to-open drawer for tablet and medication

Fig. 6. Different usages of the robot

V. Conclusion & Future Work

In this paper, we described the process of developing a robot companion which can help the elderly with their mobility issues. It was developed with Care-O-bot 4 design as a basis. Currently, the robot is still a conceptual design. We are working on an operational prototype and test it in local elderly-care facilities, while keeping the commercialization potential in mind.

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