Towards a Robot for Supporting Older People to Stay Longer Independent at Home

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Summary

The paper presents the intentions and the preliminary findings of the Socially Assistive Robot HOBBIT. The goal is to come up with a robotic solution which will balance user needs, acceptance and technical performance in an economic and affordable way while providing a solution for fall detection and prevention. Falls are the main risk of older adults living alone that require moving from home to care institutions. Hence, it is a primary target area to prevent falls and, if they happen nevertheless, to react immediately to prevent aggravated causes. We present first results of user trials given six tasks with the robot. To show the effect of bonding with the user – Mutual Care – users were separated in two groups. Results indicate that users find the robot more usable in the Mutual Care condition.

Introduction

The basic idea if the EU supported project HOBBIT is to build a robotic product that will enable older people to feel safe and to stay longer in their homes by using new technology including smart environments (Ambient Assisted Living - AAL). The main goal of the robot is to provide a "feeling of safety and being supported" while maintaining or increasing the user's feeling of self-efficacy (one's own ability to complete tasks). Consequently, the functionalities focus on emergency detection (mobile vision and AAL), handling emergencies (calming dialogues, communication with relatives, etc.) as well as fall prevention measures (keeping floors clutter-free, transporting small items, searching and bringing objects, and reminders). Moreover, high usability, user acceptance as well as a reasonable level of affordability are required to achieve a sustainable success of the robot.

State of the Art

Today a few related robot projects pursue similar goals. A typical instance is the Care-o-bot (Fraunhofer), which is an expensive research platform and was recently shown to assist users in nursing homes to remind them of drinking. In an ongoing project it will be used to bring water to users in their homes and finally assist to grasp objects from high shelves [1].

Based on the willow Garage PR2 studies were conducted to show areas in which a robot could assist older persons at home [2]. They found that tele-presence, reminders, and housekeeping have been targeted most often by robot projects. They attest that open challenges are how to create easy-to-use interfaces (old persons wish to use voice commands which, however, are not yet ready for market), how to compensate for the specific age-related impairments and how to reach acceptance for long term use. Also many activities of daily life are not yet ready for robotic assistance, such as hygiene related tasks.

In a larger study of potential user needs, cleaning tasks ranked highest on the users' wish list. Participants in focus-groups and field trials also saw a big potential for robot usage for detecting falls and picking up objects from the floor. Interestingly, this has not been investigated in depth so far.

The Approach

The robot we present here not only sets out to close several of the above mentioned gaps, it al-

so addresses the even more critical factor how to bring robots thus close to old persons that future users will readily accept it in their homes.
In order to achieve the goal of high user acceptance, the concept of "Mutual Care" is proposed, an interaction design framework for assistive robots to facilitate relationships with their users. Its main idea is the mutual understanding of each other's needs. Thereby, the robot learns the habits and preferences of the user to adapt its communications and behaviour. At the same time, the user adapts to the robot's intellectual and physical capabilities. In Mutual Care, the focus is on the conjoint adaptation and on strategies that follow the dynamics of real social relationships.
The theoretical framework for Mutual Care has been derived from a threefold basis. First, the sociological paradigm of "social roles" helps to understand the process of embedding robots within the social network of our target group. Second, the "helper theory" describes the social dynamics of mutual-aid groups. And third, the concept of "mental models" from cognitive psychology guides us to develop user-adaptive behaviour repertoires for HOBBIT.

Mutual Care Paradigm

The Mutual Care interaction paradigm focuses on the imitation of social aspects essential for human-human relationships via different interaction strategies in order to increase the user's acceptance towards the robot. An interesting relationship dynamic can be observed within self-help or mutual-aid support groups [3]. A self-help group is an alliance of individuals who need each other in varying degrees, to work on certain common problems. Some members of such groups continuously switch roles between "helper" and "help receiver" and consequently perceive an increased benefit of the group [4] compared to members who only receive help and do not switch their roles. Thus, situations where one member of the group fails to accomplish a task does not negatively affect the others' acceptance of this member, especially if an often changing "helper-help receiver" relationship is established and the group is perceived as beneficial.
We believe that one key to demonstrate mutual-aid dynamics between humans and robots are reciprocity fostering dialogues. These robot dialogues could be used to establish a recognizable, reciprocal "helper-help receiver" situation. For example, the robot politely asks the user for help if it cannot accomplish a task, and offers the user to return the favour to maintain their "helper-help receiver" balance. To test this assumption we conducted an empirical user study with potential end users.
The study was designed to test the difference in the user perception of the Hobbit robot with a reciprocity fostering behaviour and the Hobbit robot with normal dialogue behaviour. The study was based on specific hypotheses towards the establishment and the effects of reciprocity.
The first hypothesis says that in the reciprocal dialogue group, a mutual-aid dynamics between human and robot will be established. In a reciprocity situation the users will help the robot if it asks for help. The participants will react with a spontaneous positive emotional response if the robot asks for help. Once involved, the participants will not stop the helping process. The participants will give the robot the chance to return the favour. The participants will react with a spontaneous positive emotional response if the robot asks to return the favour.
Other hypotheses are that the participants will recognize the reciprocal dynamics between themselves and the robot during the reciprocal situation. And, the experienced dynamics of the reciprocal situation task will increase the perceived reciprocity of the subsequent neutral situation.

The HOBBIT Robot

The care robot in our studies was designed to enable older people to stay longer in their homes, following three main criteria:

1. Emergency detection and handling,
2. Fall prevention, and
3. Providing a "feeling of being safe and supported".

It was important that the concept created a maximum of usability and acceptance while keeping affordability at a minimum. The functions and the social behaviour of the robot were designed to complement each other.

There is this ideal of a robot butler in people's minds inspired by science fiction, which takes over various household tasks, cooks the most delicious foods, and is their best friend when they need one. The findings of Beer and colleagues [5] support this image and underline the importance of older adults' need of assistance in various household maintaining tasks such as making the bed. However, state-of-the-art platforms are so far not really capable of doing these tasks. In order to avoid over-promises, the idea for the Hobbit robot (see Figure 1) is to have an affordable technology at disposal that performs meaningful tasks and is "honest" about its capabilities by asking the user for help in reciprocal dialogues and following the basic principles of Mutual Care [6].

Figure 1: Hobbit the Mutual Care Robot - "naked" (left) and in cover (right).

The detection of falls and calling for help are considered the most popular tasks for a service robot that should support aging in place [7]. Consequently, the main functionality of the Hobbit robot is emergency detection and handling. Although a very important function, emergencies do not occur regularly every day. To allow a daily use of the robot, other functions were also added. These functions especially support fall preventions by means such as picking up clutter, bringing objects and offering entertainment which includes mental games. Additionally, the robot is connected to an Ambient Assisted Living (AAL) environment, which issues warnings when something is wrong, and thus keeps the user reassured with calming dialogues that she is "safe and supported".

The interaction with the user is designed to support multi-modality including automatic speech recognition (with an off-the-shelf solution allowing a minimal set of commands), text-to-speech, gesture recognition, and a graphical user interface with touch, in order to combine the advantages of the different modalities. The touch screen is the most reliable of the options, but requires a rather short distance between user and robot. Speech recognition allows a wider distance and hands-free use, but has the disadvantage of being influenced by the ambient noise level. Gesture recognition also allows a wider distance and additionally works in noisy environments, but needs the user to be in the camera field of view with certain lighting conditions.

Figure 2 shows the touchscreen main menu and all functions of the Hobbit robot that were implemented in the first prototype. There are three commands for daily tasks: "Clear Floor" for the robot to pick up things from the floor, "Learn Object" for the user to teach the robot objects that it should remember, and "Bring Object" for the robot to search and bring previously learned objects. Additionally, there is a "Call Hobbit" command, which can be issued verbally, per gesture or via stationary call buttons in the AAL environment.

The emergency command "Help me" is triggered in different ways: via SOS button on the touchscreen, via physical button on the robot, via speech or gesture. Furthermore, the robot detects if the user falls while being in the camera field of view.

The telephone connects the user to friends and relatives. Information about news or local weather as well as internet is available. Entertainment is provided in form of music, videos, and games. The user can reward Hobbit by saying "well done" or using the "reward" button on the touchscreen.

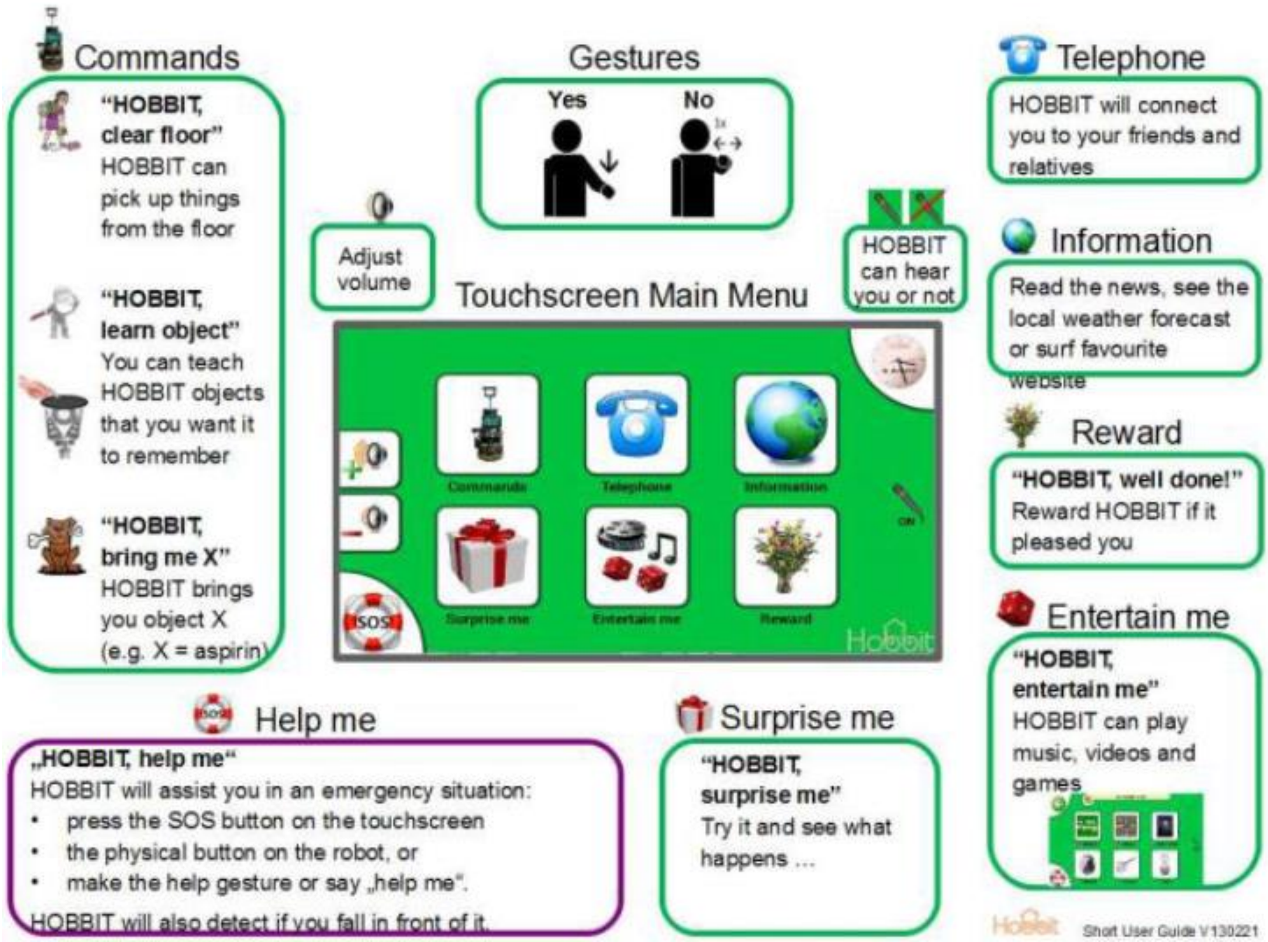

Figure 2: Interaction Possibilities with HOBBIT.

Likewise, Hobbit can offer a surprise (a randomly chosen entertainment option will appear) or the user can actively ask for it.
More details on the Hobbit robot can be found in [8] and http://hobbit-project.eu.

The First User Trials

The user studies took place at all three testbeds in a setting consisting of two adjacent areas with separation screens and a doorway in between. The first user studies were conducted in March 2013 in Austria, followed by trials in Greece in April, and finally the trials in Sweden in early May.
At all sites there was a Briefing Area – a kitchen that consisted of a kitchen corner (sideboard, a small oven, a cooker, dishes, dishtowels and cutlery) and an eating area with a table with two chairs and a side table.

The other area was the Main Testing Area (see Figure 3), decorated as a living room with a cosy chair for the PU, a small couch table, a chest with drawers, and a space in the background for the SUs and the observers.

Figure 3: Main testing area in Austria.

At the trials, the following persons were present:

- Primary user (PU)

- Facilitator: a researcher who introduced the robot and guided the user through the trial tasks.
- Secondary user (SU): in some cases, a SU accompanied the PU and remained in the background observing the trials.
- Observer: a researcher who remained in the background and observed the users' behaviour and reactions or incidences during the studies, such as unexpected reactions from the participants and technical problems.
- Technician: a researcher who also remained in the background to navigate the robot with remote control and assure that the robot functioned correctly, especially during learning, object recognition and grasping, which were autonomously done by the robot. This semi wizard-of-oz setting ensured the same testing conditions for every participant.

Each trial consisted of three parts: (1) the introduction phase, including a pre-questionnaire and briefing on how to interact with the robot and what it can do, (2) the actual user study with the robot (six trial tasks) and (3) the debriefing phase. One trial lasted on average two and a half hours (including introduction and debriefing questionnaire).

Results

A first version of the robot and its performance with six tasks to support older persons at home was evaluated in a first round of user trials (the results will be reported in detail if the full paper).
Overall the main evaluation goal is to explore the following main question: Do older adults experience HOBBIT and its Mutual Care aspects as suitable means to maintain independent living in their private household? In order to make this overall guiding research question operational and measurable in empirical research, we developed user trials in three countries and structured the findings into three main evaluation concepts: usability, user acceptance, and affordability. Figure 1 shows three examples of the six tasks, including also an initialisation phase, and learning and bringing an object where the user had to help the robot locate the object as a special mutual care task.
The user trials have been conducted in Austria, Greece and in Sweden. The trials with a total of 49 primary users (PU) and 35 secondary users (SU) followed a clear sequence of the six tasks. Participants were divided into a Mutual Care and a non-Mutual Care condition, in order to examine and compare the differences.

Fig. 4: Three of the six robot tasks: bring an object, pick-up an object from the floor, and detect an emergency situations (here acted out by a young colleague in the user trials).

In Figure 4 exemplary pictures from the trials are presented: Hobbit brings an objects from the floor to a user (left), Hobbit learns a mug (middle), and Hobbit detects a user fall and calls for help (right).
In the following we present the differences in the perception of the interaction with the Hobbit robot for participants in the reciprocal dialogue condition compared to the control condition.
In the reciprocal dialogue group, during the Task “Bring Object with Failure” a mutual-aid

situation was created by purpose. The robot failed to bring the demanded object, asked the user for help, and then succeeded with the help of the user. Subsequently, the robot offered to return the favour. The mutual-aid dynamics were explored by using the observation protocols. As Figure 5 illustrates, compliance as well as emotional responses were in general positive or at least neutral during every step of the task. These results support hypothesis 1. The observation of the established mutual-aid dynamics is the basis for the results on the attitudinal level discussed in the next sections.

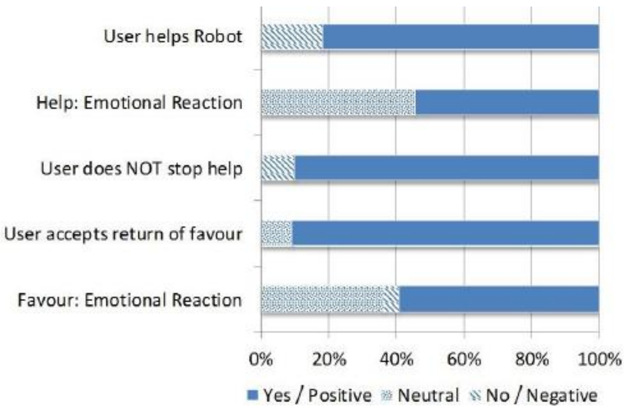

Figure 5: Results for hypothesis 1 concerning the mutual-aid dynamics between human and robot during the reciprocal task "Bring Object with Failure".

Though long-term bonding clearly cannot be observed in a controlled laboratory study, our results indicate enduring effects in the reciprocal dialogue group after the actual trial has ended. Comparing the mean ranks of the reciprocal dialogue group with the control group revealed the following significant differences: The robot was perceived as easier to use. Participants in the reciprocal dialogue condition had the impression that there was less to learn before get going with the robot. And once experienced, users of the reciprocal dialogue condition did not want to miss the "return of favour" interaction.

Conclusion

We presented initial results of user trials with the HOBBIT Mutual Care robot. Tests clearly indicate that older adults are first sceptical if the robot could help them. The task of picking up objects from the floor is typically the point when this perception changes. After slightly over two hours with the robot, the nearly all users indicate that the robot could be very helpful. Tests also show that the Mutual Care paradigm creates reciprocity between user and robot to help each other. This has a positive effect on perceived usability of the robot. In particular it turned out that used would not want to miss a function to return a favour. More details on the study are presented in [9].

Future work will improve the robot to operate in a faster way and to work in private homes where the next rest will be conducted.

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