Living with a Mobile Companion Robot in your Own Apartment - Final Implementation and Results of a 20-Weeks Field Study with 20 Seniors*

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***Abstract*— This paper presents the results of the German research project SYMPARTNER (4/2015 - 6/2018), which aimed at developing a functional-emotional, mobile domestic robot companion for elderly people. The paper gives an overview of the developed robot, its system architecture, and essential skills and behaviors required for being a friendly home companion. Based on this, in a long-term field study running from January to June 2018 both technical aspects regarding the practical suitability and robustness of the robot under domestic operating conditions and social scientific questions on usability and acceptance of the robot and the users' familiarization with their new housemate were evaluated. In the field study, two of these autonomous companion robots were used in 20 senior households in Erfurt (Germany). All participants lived with their robot in their apartments for one week without the need for supervising or supporting persons being present on-site. The tests in 20 single-person households in the age group 62 to 94 years (average 74 years) provided important insights into the special challenges of domesticity from a technical, social scientific, and user-oriented point of view. The results of the study show how seniors can shape their everyday life with a companion robot and how quickly they get used to the new housemate.**

I. Introduction

Continuing our earlier work on socially assistive domestic robots [1], [2], [3], the aim of the project SYMPARTNER (Sympathetic Partner, duration: 4/2015 - 6/2018) was to develop a novel functional-emotional robot assistant for elderly people in the domestic context. The functional aspect is aimed at safety, everyday assistance and communication. The emotional aspect of the machine, realized by a new design (see Fig. 2) and corresponding behavior of the robot companion, should increase its acceptance by its users and their quality of experience with the robot. To this end and in the light of earlier work on a third ontology [4], a novel hybrid robotic solution was developed in between a "thing" (technical device, furniture) and a "human" that should have capabilities that are rooted in their "thingness" rather than "humanness", such as endless patience, unconditional subordination, not to take things personally, etc. [5]. This had the following implications on the robot's communication and behavior in its role as "friendly housemate":

- It must have a polite and animated attitude, never patronising ("How about a little walk?").

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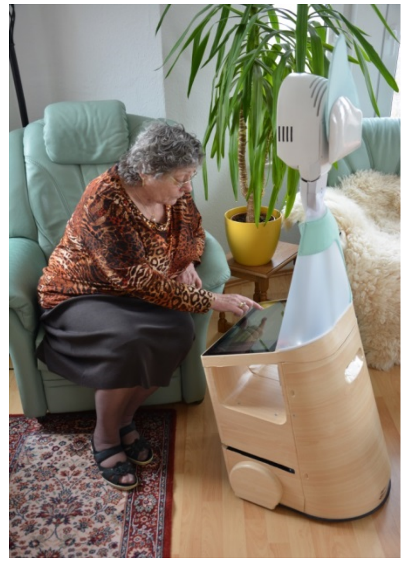

Fig. 1. SYMPARTNER robot in interaction with its user in her private home. Here, the user is responding (via touch screen) to the robot's request after the robot has approached the user autonomously and suggested an activity (e.g. "Today is nice weather, don't you want to go for a walk?")

- It remains respectful and calm at all times, even when its user is rude or insulting.
- It can make mistakes and then asks for help ("I've lost my orientation; can you help me?").
- It can act surprisingly and fall out of character (e.g. dancing unannounced).

The interaction concept developed for such a companion robot requires that it can act completely autonomously in the home. This enables it to actively approach the user, support and entertain him or her, and offer cognitive and motor stimulation to make everyday life more varied and joyful. The support was realized in particular by four scenarios:
(i) a daily morning ritual for a successful start to the day,
(ii) an evening ritual with a personal good night greeting,
(iii) farewell or greeting at the apartment door, as well as
(iv) reminder functions of health factors and appointments.
Since a cloud-based speech recognition was not implemented in the project for reasons of privacy protection, communication between user and robot only takes place by simultaneous output of the robot dialogues via speech and text and user input via touch display. During the field tests in 20 senior citizens' apartments where the robot companion should interact with its user completely alone, we wanted to get answers to the following research questions:

- Can we achieve a level of system robustness that allows the robot to operate as flawlessly as possible in the

apartments over the period of a complete field test?
- How can the developed scenarios (see above and Fig. 3, "Scenario Layer") be successfully embedded into the user's daily routine? Are the scenarios perceived as enrichment or as a disturbance?
- Is living with a robot companion attractive for older people living alone? Does a robot companion make everyday life more joyful?

Against this background, the objective of this paper is to report whether our functional-emotional robot i) is robustly functioning over longer periods of use without technical on-site support and ii) can provide functional and emotional benefits to the elderly and improve their quality of live.

II. Related Work in Domestic Assistive Robotics

Meanwhile, there already exists a whole bouquet of mainly research-oriented projects trying to develop more or less autonomously operating, socially assistive robot companions for domestic use and healthcare. Some of these robots were already used in exploratory pilot tests in nursing homes to see how the older people engage with the robot, but only very rarely in the users' private homes. Among the first group are EmotiRob [6], FLORENCE [7], HealthBot [8], Robo M.D. [9], Mobiserv [10], DOMEO [11], ALIAS [12], ENRICHME [13], or GrowMeUp [14]. Assistive companion robots were also developed for people with cognitive impairment, e.g. in COMPANIONABLE [3] or MARIO [15], but for this target group they have to deal with special usability constraints and concentrate on cognitive stimulation. User studies with companion-type assistive robots that completely autonomously operate in private homes of their users and assist them in their daily routines over several days without the presence of experts are, however, still a very rare exception. The project SERROGA [1] was a first step in this direction. It aimed at developing a robot companion for domestic health assistance for older people. SERROGA could already refer to a case study conducted with nine seniors (aged 68-92) in their own homes, investigating both instrumental and social-emotional functions of a robotic health assistant. The robot companion accompanied the seniors in their homes for up to three days assisting them with tasks of their daily schedule and health care. It interacted completely alone with the seniors without any supervising persons being present on-site. The project HOBBIT [16], [17] aimed at developing an assistive home service robot for fall detection and prevention, providing various services (e.g. picking up objects from the floor, employing reminder functionalities). The HOBBIT team did a further important step and conducted field trials in the households of 18 seniors living on their own with 5 HOBBIT robots in Austria, Greece, and Sweden. The trials lasted 21 days for each household, resulting in a total of 371 days. In 226 days the robots were used in a so-called "Device" mode and in 148 days in a "Companion" mode, however, the differences between these two modes are not further explained in [17]. The field trials revealed that several functions of the HOBBIT robots still lack stability over time, particularly the picking-up objects, follow-me, or emergency functionality. In summary, it can be said that most of these robot companions only have an instrumental function – namely assisting users in reminding, entertaining, or picking up objects. In SYMPARTNER, however, besides the pure instrumental functions of the robot a user-robot relationship is to be established. In this relationship such social-emotional factors, like co-experience, the feeling of safety when interacting with the robot, motivation and empowerment, as well as joy of use [18], play an important role for the acceptance of such a domestic robot companion.

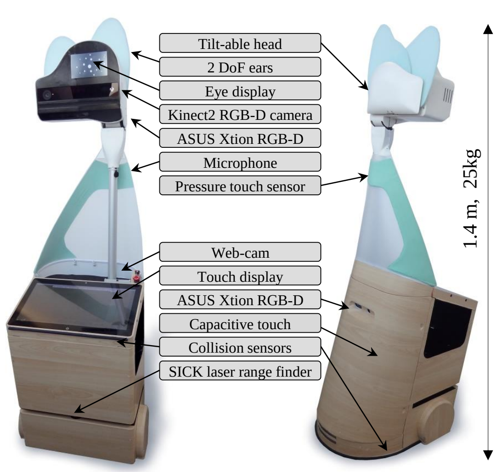

Fig. 2. SYMPARTNER companion robot with its main sensors, actuators, and interaction devices; conceptual design by University of Siegen [5]; construction and implementation by MetraLabs GmbH Ilmenau.

III. The Sympartner Companion Robot

The guidelines for the design of the robot companion were based on extensive user requirements analysis in the first phase of the project and the idea to develop a robotic "being" in between a "thing" (technical device, furniture) and a "human" [5]. Fig. 2 shows the final version of this robot that can be easily integrated in a home environment due to its abstract shape and the wooden optics. Its mobility is based on a differential drive, additional degrees of freedom are the tiltable "head" and two rotateable "ears" to be used for communicating emotions. The robot has battery capacity for about 4 hours of mobile operation. In order to allow for a 24/7 availability, the robot is able to autonomously recharge on a charging station using the technique presented in [1]. The footprint of 45x55 cm is chosen to be as small as possible in order to allow for navigation in narrow indoor environments. For navigation purposes, the system is equipped with a SICK laser range scanner, two ASUS Xtion RGB-D cameras on the back and on the head facing downwards. For people detection, a Kinect2 RGB-D sensor is mounted at the tiltable "head". As installing a robust voice control on the robot was not technically feasible (no cloud-processing desired by the seniors), the communication between user and robot was facilitated via voice output and simultaneously displayed as text on the touch display. To recreate a form of dialogue, the robot's speech output and

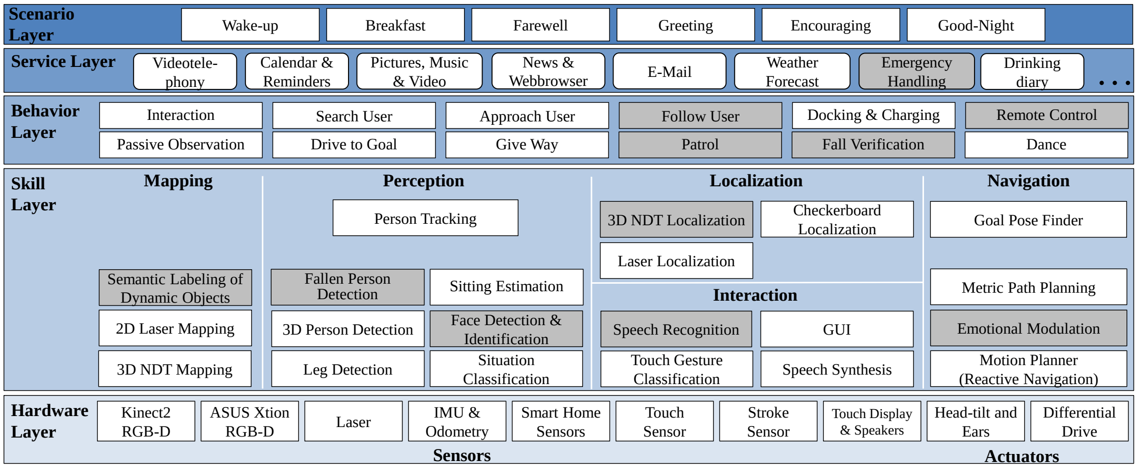

Fig. 3. System architecture of the SYMPARTNER system. Only the skills, behaviors, services, and scenarios in white boxes are of relevance for this paper, as they are those components that were finally used in the field study (see Table I for a brief description).

the user's feedback are visually represented on the display in the form of parallel speech bubbles. The user was able to scroll through the entire conversation to trace all previous dialogues. In order to access the functional services, the users had to familiarise themselves with the robot's menu structure as the robot has no voice input.

Since tactile interaction in our former robotic projects [1], [3] improved the emotional bond between the system and its user, the new robot also got capacitive touch sensors at the base and a pressure sensitive textile sensor array at the back side of the neck (see Fig. 2, right). In this way, the user (i) can push the robot with drive-assistance or (ii) communicate his agreement or displeasure with the robot's behaviour via a simple haptic feedback which led to certain ear movements or typical noises (giggling, cooing) of the robot. A last interaction device is an animated eye display expressing the internal emotions of the robot due to a set of moving bubbles. The integration of several storage capabilities is base for a personalization and allows the robot to carry around newspapers and personal items of the user.

Continuing the ideas of a layered system architecture, which in our shopping guide robots [19] have already proofed to be useful for organizing software components, five layers have been defined for the SYMPARTNER system. Fig. 3 shows them in an overview of the main software and hardware components. The top most and most abstract layer is the "Scenario Layer", which comprises scripts for realizing complex interaction scenarios as defined by the designers. These scenarios are mostly sequences of inputs and outputs, while the robot makes use of behaviors and services, which are defined in subsequent layers. The scenarios are triggered by the *Situation Classification* skill or simply by time, e.g. for the *Good-Night* scenario, and involve an active approaching to the user at the beginning of the respective scenario. The second layer, the "Service Layer", comprises all services the robot can offer to its user. These are individual GUI-programs that work relatively independently from the robotic functions just using the display, sound outputs, and the emotional expressivity by means of the head's features.

TABLE I

OVERVIEW OF METHODS USED FOR THE SKILLS SHOWN IN FIG. 3

Perception Skills	**Brief description**	**Ref.**
2D obstacle mapping	Occupancy grid map with cellsize of 3 cm built up from laser scans	-
3D perception & environment modeling	3D NDT map with cellsize of 5 cm built from 2 RGB-D sensors (tiltable Kinect2 and ASUS Xtion in the head) in an area of 5x5m around the robot	[20], [21]
Dynamic obstacle classification	IRON bag classification on local NDT map used during global mapping for semantic labeling of furniture	[22]
3D Person detection / Fallen person detection	IRON feature distance-based segmentation in the NDT map and distance-based classification of clusters by soft encoding of IRON features	[23]
Laser-based leg detection	Generic distance-invariant features with Adaboost classifier	[24]
Sitting estimation	Height threshold for cluster center in NDT map	-
Face detection and identification	Cascaded convolutional neural networks for detection; SphereFace approach for feature extraction and cosine similarity for matching	[25], [26]
Touch gesture recognition	Hand-crafted set of statistical features with Gaussian Mixture Model classifier	[27]
Navigation Skills	**Brief description**	**Ref.**
Self-localization	Usage of aMCL with 2D occupancy grid maps and 3D NDT maps	[20]
Metric Path Planning	Two stage Dijkstra on static and dynamic occupancy grid map to find intermediate goals when path is blocked	-
Motion Planner	Evolutionary motion planner (EMP) with tailored objective functions	[28]
Emotional movements	Learned objective function for EMP used during goal-directed navigation	[29]
Goal Pose Finder	Particle swarm optimization for Search and Approach User positions according to tailored objective functions	[30]

Services can be selected directly from the menu while the robot stands still, or are actively offered to the user by the robot. Third layer is the "Behavior Layer", where all the autonomous and user-centered navigation behaviors are implemented. These more complex control loops make use of the robotic basic functions for perception and navigation implemented in the "Skill Layer". Behaviors as well as services and scenarios are exclusively active. Behaviors additionally form a hierarchy, since complex behaviors can make use of others if necessary. The "Skill Layer" comprises all the software modules, which permanently run in parallel

TABLE II

OVERVIEW OF THE TRIAL PARTICIPANTS

Participants		**N=20**
Age	Average	62 – 94 years 74.4 years
Sex	Female: Male:	16 (80 %) 4 (20 %)
Education	Secondary school: High school:	N=11 (55%) N= 9 (45%)
Health status	Mobility impairments: Cognitive impairments Wearers of glasses: - strongly impaired: Hearing aid users:	N=15 (75%) N= 4 (20%) N=20 (100%) N= 4 N= 4
Technical expertise	Internet: Cellular phone: Internet and/or cell phone	N=15 (75%) N=14 (70%) N=18 (90%)

in order to realize basic functionalities. Here, sensor data are processed in order to build up a 3D model of the environment for people perception and obstacle avoidance. Furthermore, a multi-modal people tracker is engaged, which combines detection hypotheses from a laser-based leg detector, a 3D person detector, and the Kinect2 SDK. Localization and navigation modules are also part of the "Skill Layer". At the bottom, there is the "Hardware Layer" with all the sensors and actuators used on the robot. Besides the standard sensors also used on many other robots, for the SYMPARTNER robot the above-mentioned touch sensor has been developed [27]. Additionally, the robot has an EnOcean gateway, which allows the robot to receive events from smart home sensors (PIR sensors and door switches), which are used for situation classification and estimation of user presence in the apartment. Since a detailed overview on the methods integrated into the system is beyond the scope of that paper, Table I summarizes the used components and gives references for further reading.

IV. FIELD STUDY IN PRIVATE SENIOR APARTMENTS

A. *Preparation of the Field Study*

The most important requirements for an active and joyful use of a companion robot are a robust and stable running system that can ensure uninterrupted autonomy over days and weeks without the need for supervising persons being present on-site. Therefore, we had to guarantee that all required skills and behaviors (see Fig. 3) did work as expected in the domestic setting. To this end, a series of function and stress tests was conducted from mid to end 2017 in order to ensure a robust autonomous operation over a whole week. All functions were tested in our living lab, followed by tests in the private apartments of the project staff, and then by a stress test in the private apartment of a volunteer senior. The stress test was limited to 2 days, while extensive tests in the staff apartments took several days. After several iterations and some necessary improvements, the robots were released for the field study beginning in January 2018.

B. *Procedure of the Field Study and Evaluation Concept*

Similar to [1], the field study was designed as an exploratory case study to gain detailed knowledge regarding similar but highly individual cases. In our study, 20 cases were chosen to capture typical circumstances and conditions of everyday situations and provide a suitable context to answer the research questions outlined in Sec I. All users (4 male, 16 female participants) aged 62 to 94 (average 74 years) were recruited from two different service residential complexes for older people, AWO and ARTIS - both situated in Erfurt (Germany). A brief characteristic of the 20 trial participants is given in Table II. All users were living alone in their own apartments within these residential complexes managing their daily life independently.

The field study covered the period 1-6/2018 and included 128 days in total. Each of the 20 study participants could use the robot companion for seven days. Due to the availability of two identically equipped robots, two user tests could be carried out per run every 14 days. Except for the first and the last day of each test, the robot remained in the homes for a continuous period of five full days without the need for a technician to be on-site. This long test period should allow a certain amount of adaptation to the robot and reduce the novelty effect. In order to enable a natural handling of the robot by the users, there was no on-site support, so that the users could independently discover and use the functions of the robot. Via a remote maintenance access, it was possible to solve minor problems (e.g. restarting a crashed program) and to check the proper functioning of the system.

On the day of robot installation (day 1), the robot was set up on site (mapping of the apartment, definition of navigation goals), and the test persons were instructed in the functions and operation of the system. For the following test, very low obstacles (below 10 cm) were removed from the pathway of the robot, and problematic carpets with too high carpet edges were removed or fixated. Additionally, the users were instructed how to help the robot by simply pushing it, if navigation problems occurred, or the interaction pose taken by the robot was not comfortable. Over the following five days, the users interacted with the robot independently without supervision. Since the users did not have any given schedules or scripts, they were free to use the robot as they wanted. Users could, however, request administrative, technical, and personal support at any point during the trial. From day 2 to day 5, daily structured telephone interviews were conducted (in the early evening). On day 6, the user test ended, and the social science partners conducted a final interview (approx. 2 hours) in the user's apartment. In these final visits, a rich mix of qualitative methods was used: in-depth interviews, structured questionnaires, and visual documentation. On day 7, the robot and sensors were uninstalled, and the robot was returned to the university to be prepared for the next test.

C. *Results Regarding Technical System Robustness*

One aim of the project was to achieve a level of system robustness that allows the robot to operate failure-free over the period of a complete user test (1 week). As already practiced in the previous project [1], throughout the whole field trial, the users' daily activities were logged on the robot in so-called "usage & event logs" for automatic recording

TABLE III

RELIABILITY AND AUTONOMY OF THE ROBOTS

User ID	Time at User	LifeTime	Driven Distance	# Activities by Robot	# Activities by User
1	151.6 h	149 h 98.3 %	1613 m	-	-
2	169.0 h	138 h 81.7 %	1611 m	-	-
4	150.2 h	148 h 98.5 %	2360 m	-	-
9	151.1 h	59 h 39.0 %	527 m	-	-
10	146.7 h	144 h 98.2%	1105 m	-	-
11	171.5 h	157 h 91.5%	471 m	-	-
12	148.0 h	146 h 98.6 %	758 m	-	-
13	151.4 h	138 h 91.1 %	1008 m	-	-
15	132.9 h	126 h 94.5 %	1532 m	-	-
16	125.8	123 h 97.8 %	663 m	32	147
17	151.0 h	144 h 95.0%	854 m	94	53
18	199.6 h	190 h 95.2 %	1565 m	135	180
19	172.6 h	160 h 92.7 %	1320 m	119	88
20	148.2 h	142 h 95.8 %	1201 m	68	106
21	144.9 h	138 h 95.2 %	2015 m	91	98
22	148.8 h	130 h 87.4 %	1727 m	117	129
23	150.1 h	145 h 96.6 %	1491 m	121	105
24	126.4 h	107 h 84.7 %	848 m	49	134
25	171.1 h	150 h 87.7 %	1748 m	101	102
27	152.1 h	120 h 78.9 %	991 m	77	104
$\sum$	**3063 h**	**2754 h 89.9 %**	**25.4 km**	**1004**	**1246**

of robotic service usage, driven distances, the number of activities initiated by the robot or by the user, malfunctions, activated skills and behaviors, and unexpected events. The event logs were analyzed regarding these data, intensity of using the robotic services, and typical usage patterns. Table III illustrates the reliability and autonomy of the robots at the different users. It shows the time the robot was present at the user's home from installation to deinstallation. This takes 3,063 hours for both robots over the entire user study. In addition, it was recorded how long the robot was out of operation due to malfunctions. This was the case, for example, if the robot had lost its location in the apartment and could not get to the charging station alone. In these cases, the user's help was necessary to push the robot onto the charging station and restart the system by turning the key. In the user test, both robots were out of operation for 311 hours and were not available to the user. During the rest of the time, the robot was in use, could be used by the senior or offered its functions independently. This LifeTime was 2,752 hours for the entire test, which corresponds to an availability of 89.8%. Test runs with a LifeTime $> 95\%$ are highlighted in green. Most failures during the tests were caused by failed docking attempts and hardware failures (e.g. the robot rolled away from its loading station because the floor was uneven). Table III also shows the distances covered and the number of actions started by robots and users. During the 128 days that the robots worked together, they travelled a distance of 25.4 km. On average, the robots drove about 1.3 km within the seniors' homes in each user test. The evaluation of the log data shows that on average 113 interactions were triggered by the user per test run, while 91 interactions were initiated by the robot. For user ID 1- ID 15 activity logging was not yet included into the logging mechanism. It was only added at the end of the first half of the trials. For the remaining 11 user tests alone, a total of 1,246 interactions were carried out by the user and 1,004 by the robot. Over the entire test period, more than 4,000 interactions took place.

One of the most important functions of the robot is the search for the user within the apartment. A search is always started when appointment reminders are to be delivered, or when the robot wants to entertain its user with its functions or animate her to move. For interaction, the entire apartment is systematically searched [31], while the person tracker merges multi-modal observations from which it generates person hypotheses to be approached. A search is considered successful if a person was found at the end of the search and confirmed his/her presence by touching the display or the touch sensors. Searches ended unsuccessfully, if there was no or only an unconfirmed person detection at the end of the search. During 16 user tests, where the search behavior was analyzed, the robots performed a total of 798 searches. Of these, 620 searches were successfully completed, which corresponds to a success rate of 77.7%. The main reasons for unsuccessful searches are occlusions of the user by furniture (e.g. by the backrest of an armchair), but also the absence of the user in the apartment not detected by the SmartHome sensors. A successful search during the user test took on average 22.2 s (standard deviation: 7.8 s). Finally, it should also be mentioned that the stability of some technical skills of the robot (driving behavior, perception of persons, search behavior) was still not sufficient, especially from the users' point of view (see next section).

D. *Results from Social Scientific Analysis*

Social scientific evaluation (done by project partner SIBIS Institute of social research) was focused on the acceptance of the robot companion by its user and its impact on the user's daily routine. To this end, it followed a pre-post-design concept to compare results obtained from a comprehensive preliminary study (preceding the robots' intervention) and a main study (in which the robot was placed into the users' domestic context). The robot companion was programmed to entertain and support its user in her daily routine. This was achieved during (i) the daily morning ritual, (ii) the evening ritual (featuring a personal farewell), (iii) by greeting/sending off the user when s/he leaves/returns home, and (iv) daily reminders of appointments and health related issues. This assistance was offered by the robot completely autonomously.

As a result of the daily and final interviews it turned out that 12 participants (60%) responded positively to three of the four scenarios. During the second part of the trial (when the robot's performance was more stable than during the first half of the trial) respondents' satisfaction was 70%. Autonomous reminders delivered by the robot were also rated as helpful. They were particularly appreciated when they did not require elaborate input. So reminders of keys, weather, or umbrellas were greatly appreciated, but the entry of appointments in the robot calendar less. Further offers included motor and cognitive stimulation, as well as the reminder to drink. The robot delivered these suggestions and reminders several times a day. The concept requires that they are integrated into the user's daily life, occur casually, and are neither intrusive nor patronising. This allows the user to decide which suggestions to act on and which to disregard. It turned out, that 11 out of 20 participants (55%) reacted positively to these autonomously issued reminders. Again, acceptance increased in the second test phase, as the number of daily reminders increased, consequently increasing participants' awareness. This amplified the approval rate to 90%.

The final interviews with the respondents made it clear that the majority of them had developed a personal relationship with the robot companion during the field tests. The results also indicate that a companion robot has high potential to be accepted by older people as a meaningful social companion. This is based on the following results from the interviews:

- support in structuring everyday life was successful
- personal addressing by the robot was helpful
- cognitive/motor stimulation of the users was successful
- concept of changing everyday life by surprise was successful
- occasional support of the robot by the users kept the test persons on the go
- emotional stimulation of the users seems to be possible with aspects such as joy, worry, and humour.

However, it should not be disregarded that some of the robot's technical functions and their stability were not sufficient from user's perspective. During local navigation (e.g. in narrow passages between the furniture, when approaching the user as close as possible) the robot sometimes stopped abruptly and asked for help "*I'm a bit confused, help me, please*". It is particularly interesting that most respondents reacted positively to these shortcomings and cries for help - the users were amused, spoke with their robot, and commented on its 'stupidities'. Support and concern for the robot kept the respondents busy and ultimately resulted in cognitive stimulation ("What did it do this time? What do I do now?"). With such positive results, it is however important to remember that the majority of the testers were relatively tech savvy, patient and eager to contribute to the success of this research project. The results presented above allow the cautious conclusion that the concept of a domestic robot companion, a friendly housemate, seems to be helpful against the challenges of living alone. It would be interesting to further evaluate which aspects of this stimulation have been linked to the robot's friendly behavior and which have been implicitly influenced by social expectation.

V. Conclusions and Outlook

All in all, SYMPARTNER can refer to 20 weeks (128 days) of field study in 20 senior apartments where both companion robots interacted completely alone with the elderly without any supervising persons being present onsite. The achieved results demonstrate that most skills and behaviors of the robot did function autonomously. Only in a few cases of local navigation did issues occur, so that the robots had to ask for help from the users. This illustrates the already achieved maturity level of the implemented methods for navigation, interaction, and service offers, which is the essential prerequisite if one wants to objectively study the user experience and social acceptance of companion robots in everyday experiments. Further research needs to clarify exactly which support-related services are most promising to meet the users' expectations and how instrumental and social-emotional functions of the robot best work together over longer periods of time. However, for such a long-term field test up to three months, the following challenges still have to be handled: The technical robustness of the robot platform must be further improved. In addition, a technical support concept with less remote-support effort is necessary. Since 24/7 video observation of the study participants is not possible for legal and ethical reasons, the combination of daily and final interviews with the subjects and indirect observation of their activities in their homes must be refined by evaluating the recorded log data. From navigation and HRI point of view, for such long-term field tests there is still an urgent need for improvements, e.g. in:

- robust recognition of the actual user (target person) for use in multi-person households or in single-person households with a large number of visitors
- treatment of furniture displacements so that flexible navigation to mobile destinations is possible, e.g. "Move half a metre in front of my favourite chair".
- navigation even through very narrow passages with only a few centimeters of free space to the left and right
- integration of simple but robust voice control to be able to give instructions even over long distances.

Moreover, various design modifications of the robot are also necessary. For example, the drive must be able to overcome higher carpet edges, thresholds, and other unevenness, so that this does not remain an exclusion criterion when selecting testers. Moreover, the mounting of the touch screen must be changed so that it is also easy to operate while standing.

As a vision of the SYMPARTNER project, we see a robot companion, that is living together with its user in a long-term interaction situation. As we expect the evolution of an emotional binding of the user to her robot over time, which is reinforced by the ability of the system to adapt to the user's needs and preferences, adaptation and learning techniques and new intuitive modalities for getting an immediate user feedback (e.g. via haptic feedback or recognition of the user's facial expression) are required to quickly personalize the interaction behavior of the robot to its current user.

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