Development and field test of a companion robot supporting older adults in their own homes

PhD thesis

Katalin Zsiga MD

Semmelweis University
Doctoral School of Clinical Medicine

Supervisor: Gábor Fazekas MD, PhD
Official reviewers: Antal Péter MD, PhD
Anna Polgár MD, PhD
Head of the Final Examination Committee: Pál Géher MD, PhD
Members of the Final Examination Committee: Ágnes Mayer Dr, PhD
Cecília Varjú Dr, PhD

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1 Introduction

In industrialized countries the prolonged life expectancy and the growing number of older adults presents increasing financial and physical burden for society. Their support, care, supervision means for the relatives, nursing staff, and social care system significant material and time expenditure, while the available resources are finite.

There are several options to solve this problem. The development of information and robot technology nowadays is an alternative way: assistive technology can solve the problem at some level. They are able to take on certain tasks with new technology innovations such as patient surveillance systems, smart homes or assistive robots.

Robots are programmable sensory-based mechatronic devices. Complex movement and / or object manipulation can be performed partially or completely independently. They can be programmed as required, while acting within the limits set by the person performing the programming, acting on the basis of the user's decisions. The International Federation of Robotics distributes robots to industrial and service robots in accordance with the intended design. According to their definition, service robots are partly or completely self-contained devices that provide services to people or machines, but do not include industrial uses.

Robots used in rehabilitation can be divided into two large groups. One group is used in therapy and in condition and function assessment. The other group is assistive robots. Their task is to provide physical or cognitive support to people with disabilities or the elderly in need of everyday life and self-reliance, thereby enhancing their independence and, as far as possible, living longer in their own home, in their usual environment, to improve their quality of life.

In the last two decades a lot of projects have dealt with the production and development of assistive robots. Up to now only a few controlled clinical trials have evaluated the impact of the use of robotic technology on everyday life, home care or housework, and they have also been in a controlled environment. However any assistive robot has not been tested for long-term original home environments so far.

The Domeo project was established in three countries by co-operating of eight institutions. From Hungary participated in the National Institue for Medical Rehabilitation, the Budapest University of Technology and Economics and Meditech. The aim of the project was to develop, test, survey user needs and scan human-robot interaction. During the three-year term, the main sections were: a focus group interview was conducted to measure the needs of potential users and their relatives. The robot gone to the development and laboratory test. In the second half of the project long-term field test was conducted in real conditions.

2 Objectives

1. Supporting elderly people living alone using robot technology to stay longer in their own home
2. Developing an assistive robot in cooperation with engineer partners
3. Assessment of user needs during the use of an assistive robot for home help
4. Test and evaluate an assistive robot for home help in real conditions
5. Research of human-robot interaction

3 Methods

3.1 Focus group interview

In the first phase of the project we organized a focus group interview at the National Institute for Medical Rehabilitation in order to ask potential users and their relatives about their opinions, attitudes, needs and expectations about a home-based service robot. The total number of participants was 11. The procedure consisted of three parts. First we introduced the Domeo project, its goals and the Kompaï robot with a slideshow and a short video tutorial. That was followed by the presentation of the robot live, demonstrating its functions: speech recognition, movement, navigation system, obstacle detection and avoidance, reminder function, shopping list creation, maintenance of Internet connection and video conference management. Finally, the participants were divided into three groups according to the possible relationship with the robot: potential users, older and younger carers. The interviews took place in an informal way, but we moderated conversations in a predetermined way.

3.2 Field test

During the project we used the first generation Kompaï robot produced by Robosoft (France). The robot was able to communicate verbally and interact with touch screen of the graphical user interface. As the field test was designed with Hungarian native speakers, the most important task was to create the graphical user interface in Hungarian and to develop a Hungarian language speech recognition and speech synthesis software.

The robot's functions were: navigation inside the home, obstacle detection with sensors and avoidance, automatic docking to the charging unit, reminder for daily activities, shopping list management, emergency alarm, health parameter monitoring, Internet based information and communication services (Skype, email), verbal communication system, entertainment.

Eight users were chosen based on our predetermined criteria: 70 years of age, alone or at least 10 hours a day alone, self-moving within the apartment, able to communicate with the robot, signed consent.

Seven women and one male participated in the field test with a mean age of 77.125 years (70-83). All of them were retired, living alone and they were self-sufficient in their everyday lives. Half of the users had computer skills before the field test.

During the field test there were tested simultaneously two robots at users home users in real conditions. The test lasted for a total of 14 months, the robots worked for about three months in the home of eight users, a robot was running for an average of 93 days (67-118).

To ensure safe and barrier-free navigation and movement of the robot the user's home had to meet predefined requirements: the flats had to be one-leveled, the doors had to be kept open, enough space had to be left for the robot to move. The protruding and fragile objects, the loose cables and carpets had to be removed and the robots had to get through the high thresholds with ramp. There had to be no pets in the apartment. At the beginning of the test the technical team picked up a map of the apartment with the robot and marked on average three main points of interest to help navigate the robot.

Participants were asked to use the robot according to their needs and capabilities. The test was conducted in a non-verified environment, and the outcome of the evaluation was not verified as everyone used the robot functions as he wanted and as many times as he liked.

During the field test there was a person on duty to contact with the user in case of an unexpected event after the robot had been alerted.

We evaluated the user's behavior, experience, and robot data in an objective and subjective manner.

4 Results

4.1 Focus group interview

In general the participants' views were: Potential users would be glad to use the robot if they had the opportunity. Older caregivers' opinion was that the robot could play a useful role in health care, but in addition to cognitive support physical support would be important. At the same time the device was not considered sufficiently advanced to provide the task it was intended for. Young carers were the most critical.

In summary: the main advantages and strengths of the robot are: making it easier for users to contact family members and doctors via Skype, communicating verbally using voice recognition software, making emergency calls to the appropriate person in case of need, reminding the user about the daily routine (eg. taking medicine). The robot can execute the verbal statements succesfully and can detect and avoid obstacles while moving. It reduces the feeling of loneliness as it is possible to speak with the robot.

The robot's weaknesses and possible barriers of use are: it is impersonal, it has a strange, unusual, stumbling appearance and it is unable to convey emotions. The apartment should be arranged and made accessible so that the robot can move and operate without interruption. The lack of the ability to provide physical assistance was a cause for concern. There is also a problem with the possibility of verbal communication only (this will be a problem if the user falls or gets bad and can not talk to the robot). Older people did not like having no "name" but only "robot". Use of the robot for interviewees is too complex for people with dementia.

The most important recommendations for the future: the robot could be able to carry objects, provide physical support, read books or newspapers, remind the user where he has left some objects in the apartment. The general opinion was, that in its present state the robot still needs improvement.

4.2 Field test

The field test was evaluated based on subjective user feedback, objective data collected by the robot and the case report forms that were collected during the visits.

In addition to the free expression of the participants, we asked to comment on the functions of the robot in terms of utility, reliability (how the function worked) and how disturbing the function was, by 1-5 scale (1 = least / worst, 5 = most / best). The most useful and at the same time the least trusted feature was the navigation and communication system.

The objective evaluation was based on data logged by the robot. The following parameters were tested:

1. Frequency of using of each feature: the most frequently selected features were the agenda, communication functions and information search services, although the movement of the robot was also popular to some users.

2. The duration of logging: the field test had reached or exceeded 3 months in case of more than half of the subjects, for others it was been shorter than a few weeks for various reasons.

3. The number of times the device was turned on did not have any conclusions about its usage.

4. Communicating with the robot: Although the average number of voice and tactical commands was almost the same, there was a large difference in the way users communicated with the robot.

5. Number of on-site visits: the high number of out-of-date visits shows there were technical issues.

Due to the low number of investigators (eight) we could not carry out a substantive statistical analysis as no significant conclusions could be drawn. We founded context between the user preferred interaction mode and age of users and available computer skills. Over the age of 80 they preferred oral interaction, while those under the age of 80 used almost the same degree of modality. Oral communication was more commonly used by users with a certain degree of computer knowledge already.

5 Conclusions

The project was implemented through close medical-engineering cooperation. The technical innovations were made by our engineer partners. I did the planning and implementation of doctor-professional tasks.

New findings made during my work:

1. I was the first to perform a long-term clinical trial with an assistive robot in the home of older adults living alone, during which I proved that coexistence of an old man and the robot is possible.
2. After the users lost their inital fears, coexistence with the robot has proved to be problem free. After proper training, older people who had no computer skills could learn to use the robot.

3. I have revealed the strengths and weaknesses of the robot, this can serve as a basis for further development.
4. An essential condition for the efficient and reliable operation of an assistive robot: in sharp situations the speech recognition and navigation system are faultless, user-friendly, customizable to meet the individual needs, ensure autonomy and respect privacy.
5. Both simplified touchscreen and speech communication can be used for communicating with the robot, even in case of older people.

6 Bibliography of the candidate's publications

6.1 Publications related to the theme of the PhD thesis

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