Needs and Solutions - Home Automation and Service Robots for the Elderly and Disabled
Panu Harmo, Tapio Taipalus, Jere Knuuttila, José Vallet and Aarne Halme
Automation Technology Laboratory
Helsinki University of Technology
P.O.Box 5500, FIN-02015 HUT, Finland
firstname.lastname@tkk.fi

Abstract – Numerous studies in the field of service robotics for elderly and disabled have been done. However, the overall user needs are rarely deeply considered. This work surveys the needs and challenges for assisted living at home for the elderly and disabled. Automation technology solutions for today and for the future to help the people to live better, safer and longer are researched.

This work is part of Future Senior Living - Assistive Automation –project. This project is shortly described. Research consists of three phases. In questionnaire-study phase opinions and needs for home automation and home robotics are analyzed. Interview-study phase includes interviews with different specialists, the elderly and disabled themselves, and excursions to care houses and other related institutions. Literature-study reveals user needs as well, but it concentrates more on solutions than the other phases. Multiple needs and solutions were found. They have been discussed and the results are presented in an organized table.

Index Terms – home automation, elderly care, home care, service robots, assistive technology

I. INTRODUCTION

The structure of population in the industrial nations is changing. There will be less people to take care of increasing number of elderly people. This problem is motivation to numerous studies also in robotics and automation. Instead of moving to care institutions, it is more desirable and often economically viable to live at home as long as possible. We are developing technology for the elderly to help them to live longer at their own homes.

Technology research and development is too often only targeted for young technically oriented people. Even in product testing and evaluation elderly people are rarely used. Much of the research is concentrated on some very narrow fields without specific and analytic research about the user needs. This research tries to find and analyze the technology needs of elderly people and to give some prospects for the solutions.

The technology here is concentrated on home robots and home automation. The term “intelligent home” is often used for home automation. The home robots are mobile robots operating in challenging home environment. If a robot is not able to manipulate anything, it still can be useful for collecting or providing information. Home robot does not even have to be mobile, like in case of [1]. But then we can ask if it is a robot any more.

Home automation is more than an automated air-conditioning system. Home automation includes some form of home network and intelligence or logic distributed around the network or centralized on a specific control unit. Survey about home automation options can be found from [2].

This research is based on literature study, questionnaires, demonstrations and interviews. Our research tries to find technical solutions for assisting independent living at home. We found that, naturally, it was important to find out the exact needs and problems on the field in order solve them.

The research project is described chapter 2. The methods are explained and results are presented in chapters 3 and 4. In chapter 5 results are analyzed and discussed.

II. ASSISTIVE AUTOMATION

A. Goals

Assistant Automation (AA) project is a part of a larger research project called “Future Senior Living” (FSL). This larger project is trying to find solutions, not only technical ones, for elderly people to live better, safer and longer at their own homes. The solutions can be new services, architectural solutions or social innovations. The FSL research group consists of engineers, architects, designers and health care professionals.

B. AA project implementation

The AA project consists of technology reviews, user interviews, designing and building of demonstration systems and demonstrations for the public. The technologies of interest for the AA project are home automation networks, home servers, home robots, wireless communications and RFID technology.

Home server or home service gateway is an intelligent device that connects home and home devices to the outside world, namely the Internet. Home server also acts as the automation controller of the home systems. An example of a use scenario is home activities monitoring. If there is an abrupt change in the level of activities as measured by various sensors at home, a notice or a warning is sent to outside home helpers.

In order to collect information and to control the various devices and activities at home, a home network, wired or wireless, is necessary. The home automation activities include
security, entertainment, communications and environment control. Some of these activities require fast real-time communications, some slow reliable wireless communications etc. It is the task of the home server to connect the various devices and networks together.

A home robot is a mobile device for moving about, performing tasks such as vacuuming, measuring, communicating, fetching objects etc. A stationary robotic arm could also be used for helping people get out of bed, to move objects in the kitchen etc. Robotic development for home assistance is still in its early stages. In Fig. 1 are presented information home robots used in project.

Fig. 1 Information home robots used in Assistive Automation project. The wheeled Rolloottori on the left and the ball shaped Rollo on the right.

RFID tags, wireless sensors, multimodal user interfaces, networked appliances, image analysis, wearable health measuring and monitoring systems, video communications, and virtual models are just some of the new technologies whose applications to assistive home automation are researched in this project. A more detailed description can be found in [3].

C. “Functional Home”

AA project includes a group of partners that are financing the work and are interested in the results. These partners range from a communal social services department, associations for the benefit of the elderly and disabled, to technology companies. Automation Technology Laboratory (AUT) of Helsinki University of Technology (TKK) cooperates closely with Toimiva koti (TK) (Functional Home), a showroom and information center for accessible living. Visitors with different backgrounds come to TK to find devices, services and solutions for accessible living for elderly and disabled people. Many people, who are planning to build or to buy a new home, where they want to live through out their retirement days are visiting TK. It is located in the City of Helsinki and it is funded by the City.

TK consists of two show apartments (Fig. 2), two exhibition rooms and a lecture room. The apartments are furnished and equipped to give a realistic impression how the various devices and systems work and look and feel in real life. People can walk in and they are welcome to try out most of the things themselves. The products are mostly commercially available. The companies, whose products are on display, pay a yearly fee for this.

Fig. 2 Bedroom of another apartment in Toimiva koti

The personnel of TK take part in the AA project research by assisting in specifying the user requirements for a home automation demonstration system. The TK personnel also assist in the user interviewing.

III. METHODS

There are two approaches in this research. First needs are researched and then solutions for the needs are constructed. For researching the needs questionnaires were used and interviews done. Co-operation with the other groups from the Future Senior Living project provided us with much information and ideas. Solutions for the needs were studied from literature, invented by our team or they were provided to us during the interviews.

A. Questionnaires

In conjunction with demonstrations of home automation and home robotics at TK, answers to our questions were gathered. Visitors visited the showroom and saw the demonstrations. After the visit they were given questionnaires that each person filled out individually. Many of the visits were done in groups, but also individual visitors were requested to participate.

The visitors were asked how interested they were in various home automation and robotics features and technologies. The respondents’ views on home care services were also enquired.

The first part of the questionnaire study was done during fall 2003 when 83 persons responded. The second part will be done during spring 2005 when approximately additional 100 persons will participate.

The questionnaire was divided into four sections: 1) general interest in assistive solutions at home, 2) interest in
home services, 3) interest in home automation functions and 4) interest in home robotics. The first two sections were more general and mostly dealt with things on display at TK and services that could be provided. The last two were effectively about functionality that could be provided in the near future.

The questions were formulated as “What interests you?” and the respondents were asked to circle their answer on a scale from 1 (not interested) to 5 (very interested). In the home automation and home robotics sections they were also asked to estimate a rough price they might be willing to pay for one feature of a system. There was also space for comments or new suggestions for services.

The questionnaire was anonymous, but some background information was requested. Majority of the participants were health or social care professionals. Only about half of them provided their age, but of those who did, were between 18 and 69 years, average being 45 years. A clear majority were women. With this sample size, it is not possible to make a distinction between different types of respondents, so the responses were treated as one group.

B. Interview

Assistive Automation project had meetings and discussion sessions with a multi profession audience. There were people present from care giving organizations, care giver educational institutes, help instrument manufacturers and researchers.

Some interviews and discussions were also done as personal meetings and personal mail exchange. No specified questions set was used because the interviewed people were specialists in their field, and the questions concerned this field of specialty. Examples of these people are:

- Development Manager, care service provider for elderly (Finland)
- General Manager, Help instrument manufacturer (Finland)
- General Director, Deaconess Institute (Germany)
- Physiotherapist, TK (Finland)
- Senior caretaker, Home care association of elderly (Finland)

Excursions were done to care institutions like:

- Havukoti, care home for mentally disoriented elderly (Vantaa, Finland)
- Kampin palvelutalo, care and service house for elderly (Helsinki, Finland)
- Altair Aoba, care house for elderly (Sendai, Japan)

Knowledge has been gathered during three year period and mainly by three researchers.

C. Literature Study

Wide variety of literature was used to do the literature study. Naturally journals [4], conference publications and health care and technical thesis works [5]. Also publications [6] from health care institutions and books like [7]

Here some examples of researches around the topic are described. Yoshimi et al. [8] proposes robotic information home appliance. This wheel based information robot is equipped with a camera and speech recognition in order to act as a user interface for other home appliances. For that and for contacting the robot from remote location, for surveillance purposes, the robot has wireless communication link.

Homma et al. [9] present a four degree of freedom leg rehabilitation system. For rehabilitation after operations etc. some joints or limbs need to be exercised while the patients are not yet able to do it by themselves. This requires monotonous and hard manual work, but with robot like this, manual work could be reduced and the amount of treatment increased.

T. Maeda et al. [10] present pet-type robot for elderly. The robot acts as a companion for lonely elderly when it is treated as a pet. It also has some information functionalities like telephone and CCD camera whose pictures can be sent via internet.

Gimenez et al. [11] present a manipulator service robot for disabled and elderly. The robot itself is an arm that has control electronics built in. The arm is a separate unit that can be connected to sockets in different locations (wheel chair, kitchen wall or bedroom ceiling) for operation. The robot gets its power trough the socket.

IV. Results

A. Questionnaire: General assistive solutions (±0.26/99%)*

In this section, the respondents were most interested in accessible living in general. When asked about particular features, aids for mobility (avg. 4.4 on a scale from 1 to 5) and lifting (4.3) were the most important. They were followed (in order) by aids and features in washroom/toilet, communication, kitchen, security, health care, furnishing, physical exercise, vision and hearing (3.8). Environment controls (3.6) were the least interesting in this category. The environment controls that are installed in TK include opening and closing doors, windows and blinds and turning lights on and off. These are the closest features to home automation. The result might suggest that these features are not needed, but it also might mean that the currently available systems are not yet useful or sophisticated enough.

B. Questionnaire: Home services (±0.29/99%)

The services mentioned were slightly less interesting than the devices and solutions in the first section. The most interesting, personal hygiene (4.2) and security service (e.g. a wristband with an alarm button that calls a security service) (4.1) were slightly above the rest: food service, electrical communication system, use and maintenance of home appliances, outdoor exercise help, transporting people and goods and helping with shopping, banking etc. (3.7). Home maintenance (3.4), manicure, pedicure etc. (3.2) and pet walking and care (2.7) were clearly less interesting.

* Values in this section are averages on a scale from 1 to 5 with maximum ±0.26 confidence interval of 99%.
C. Questionnaire: Home automation (±0.36/99%)

In this section people were asked about their interest in features that were or could fairly easily be available using current technology and home automation.

The most interesting feature to the visitors was a stove alarm system. It monitors the use of the stove and any movement in the kitchen. If the stove has been on unattended for a certain period of time, a reminding message is shown to the user by the robot. If he still does not check the situation, the stove will be turned off automatically. This system got an average of 4.7. The next system was meant for reminding of and possibly also dispensing it and got an average of 4.1. Further features in order of decreasing interest were:

- Delivering messages and controlling equipment with mobile phone (4.1)
- Universal remote controller for TV, radio and environmental controls (3.9)
- Key reminder, which reminds the user to store the keys in a certain place and take them when going out (3.8)
- Activity monitoring, alerts care personnel if there are changes to normal activity levels (3.7)
- Environmental controls by voice (3.6)
- Notification of mail in mailbox (3.1)

A very basic home automation system was already built by ATL to demonstrate the mentioned capabilities. About 70% of respondents estimated the price they were willing to pay for one single feature. The average was at 560€. This suggests that there is significant interest for this kind of systems.

D. Questionnaire: Home robotics (±0.34/99%)

The demonstration system also included a small, wheeled home robot that has a screen for displaying messages, a camera for transmitting the image and several other devices. This robot was however not always present. This might have affected the results, since for many people, a “robot” often implies a humanoid robot. On the other hand, a commercial vacuuming robot was on display, which in part explains people’s interest in it.

The features in decreasing order of interest were:

- Robot warning about dangers: break-in, fire, carbon monoxide, water damage (3.8)
- Vacuuming robot (3.8)
- Robotic manipulator, reaches for objects on the floor and in the upper cupboards (3.6)
- Robot reminding about medicine, mail etc. (3.3)
- Robot as a mobile communicator, video phone (3.0)
- Robot as a moving surveillance platform (2.8)
- Robot as an entertainer (2.5)

The interest towards home robotics was significantly lower compared to other categories. Especially interesting is that robot as an entertainer was not considered interesting. Entertainment is one of the few uses that robots (such as Aibo) have been sold to private homes. One explanation might be that the respondents were from a completely different target group. Surprisingly though half of the people estimated the price they were willing to pay and the average settled to 790€.

E. Interviews

Different kind of people gave different kind of view points to the problems. Care workers indicated that the biggest problems or the hardest tasks were lifting, dressing and undressing the patients. On the other hand it was pointed out many times that a correct technique for lifting could reduce the tress significantly. The task that takes most of the manual labor and is experienced troublesome in the elderly care house is feeding of the elderly. Hygiene of the elderly was also seen as a problem. Often the elderly participate in the food preparation, as a meaningful activity, but it is difficult to assume their hand hygiene. Personal hygiene, washing or bathe assistance, is also difficult and time consuming task.

Management of the care workers or nurses saw different problems. Time management was seen as a problem, especially in home care where distances are long (in Finland). Because of the long distances, home care workers seem to be more car drivers than care workers. Also the so called false alarms were seen as a problem. The care worker has to drive to the location to see what was the reason for pressing the emergency button. The reason could be that the patient had itchy back or needed somebody to talk to.

Elderly themselves were concerned about their safety. They had many reasonable and some not so reasonable threats. They were afraid of falling down on the floor and not being able to get up. They were also afraid of being robbed, or even getting toxic gases from ventilation or spacemen shooting rays at them. One major concern was loneliness. The elderly wished to have more contacts with other people. Naturally, contacts with friends and relatives was preferred, but almost any company to break loneliness would be appreciated. One remarkable thing was the fear of technology. New house appliances that they were not used to use were suspicious. They were afraid that the device would harm them or they would break the expensive device. Also different kind of safety wristlets and other sensors and equipment continuously worn were not very popular. They felt them as itchy, heavy and ugly or some other way irritating.

F. Solutions

Table I has been divided to four columns and the first column describes the problem from the patient’s point of view. The second column presents the way how the needs are traditionally fulfilled. This is studied at the same time with the needs and problems. Mainly the information is from visits to the care institutions and interviews with the care workers, but also the questionnaires are used. Next column presents the
robotic technologies used in real applications or available today. A criterion here is that the product or technology has to be commercial. They are found from manufacturers like the Aibo entertainment robot from Sony. They are also studied by visits to care institutions and by interviewing. Some solutions are found from literature like [6]. The last column, the robotic technology under research, is studied by reading relevant journals and conference publications.

<table>
<thead>
<tr>
<th>Need, problem or difficulty</th>
<th>Examples of known solutions</th>
<th>Automation technology or support available today</th>
<th>Automation technology or support under research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loneliness</td>
<td>Home nursing, day centers, TV, enhanced communication: Internet, email, mobile phone</td>
<td>Entertainment robot</td>
<td>Emotion robot[1], information home robot[3,8], intelligent home[2]</td>
</tr>
<tr>
<td>Preparing food</td>
<td>Food delivery, home nursing, ready made food, food automat</td>
<td>Robotic manipulator [12]</td>
<td>-</td>
</tr>
<tr>
<td>Eating</td>
<td>Home nursing, easy to eat foods, special design for fork, spoon, knife or chop sticks</td>
<td>Feeding robots [13]</td>
<td>-</td>
</tr>
<tr>
<td>Medicine dispensing control</td>
<td>Home nursing, refilled medicine containers</td>
<td>Intelligent medicine dispensers [14]</td>
<td>Intelligent home [2, 3]</td>
</tr>
<tr>
<td>Cleaning</td>
<td>Cleaner, home nursing, vacuum cleaner, motorized window cleaner</td>
<td>Floor cleaning, window cleaning robot [15]</td>
<td>-</td>
</tr>
<tr>
<td>Shopping</td>
<td>Home nursing, delivery services, catalog shopping</td>
<td>Internet shops with delivery</td>
<td>Intelligent home aware of lack of products [2]</td>
</tr>
<tr>
<td>Personal hygiene</td>
<td>More easily accessible toilets, functional toilet seats, home nursing, toiletry devices for bed, moveable toilet seat</td>
<td>Bathing robot</td>
<td>-</td>
</tr>
<tr>
<td>Passivity</td>
<td>Day centers, therapy, club activities</td>
<td>Entertainment robot</td>
<td>Home robot [8], Emotion robot [10]</td>
</tr>
<tr>
<td>Communication , mobile phone, email</td>
<td>Easy to use phones, simpler email programs</td>
<td>-</td>
<td>Information home robot[8], intelligent home [2]</td>
</tr>
<tr>
<td>Walking (reducing need)</td>
<td>Servants, furniture arrangements</td>
<td>-</td>
<td>Manipulation robots [16]</td>
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</table>

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<th>Need, problem or difficulty</th>
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<th>Automation technology or support under research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking (physical support)</td>
<td>Walking sticks, wheelchairs, walkers and rehabilitation training</td>
<td>Electric wheelchairs, power assisted bikes</td>
<td>Robotic walkers[17], exo- skeleton robots, automated electric wheel chairs</td>
</tr>
<tr>
<td>Reduced muscle power</td>
<td>Rehabilitation training, home nursing</td>
<td>Power beds, body lifters</td>
<td>Manipulation robots [16, 18]</td>
</tr>
<tr>
<td>Memory losses, dementia</td>
<td>Reminder devices, notice boards, relatives and nurses, diaries</td>
<td>Electrical diaries</td>
<td>Information home robot [8], intelligent home [2]</td>
</tr>
<tr>
<td>Reduced fine motoric skills, shaking hands</td>
<td>Home nursing, easy to use objects: mugs, taps, door handles …</td>
<td>Home nursing, easy to use objects: mugs, taps, door handles …</td>
<td>Robotic manipulators with special UI</td>
</tr>
<tr>
<td>Reduced vision</td>
<td>Eye glasses, voice indicators in devices, indication with texture or position (Braille writing, grooves, switches …)</td>
<td>Text to speech programs, speech-recognition programs</td>
<td>Information home robot[3, 8], guidance robots[18]</td>
</tr>
<tr>
<td>Motion of the completely or partly paralytic limbs</td>
<td>Rehabilitation nursing, self powered exercising machines</td>
<td>One DOF rehabilitation devices</td>
<td>Multiple DOF rehabilitation devices or robots[8]</td>
</tr>
<tr>
<td>Reduced hearing</td>
<td>Hearing devises (sound amplifiers), paper and pen, written information</td>
<td>Speech-recognition programs</td>
<td>Information home robot [7]</td>
</tr>
<tr>
<td>Heart attack, epileptic fit, etc.</td>
<td>Emergency buttons, home nursing</td>
<td>Teleoperated cameras</td>
<td>Intelligent home [2], home robot</td>
</tr>
<tr>
<td>Clothing and undressing</td>
<td>Home nursing, help instruments</td>
<td>-</td>
<td>-</td>
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</table>
V. Discussion

There seems to be interest towards using home automation and robotics to help the elderly and disabled at their homes. However, very few systems are available on the market at prices the respondents were ready to pay. In addition to the price of the devices, installation costs for (e.g., home automation systems) increase the price significantly.

There are various problems mapped for reasons for elderly to move from home to care homes. Further study would reveal the most common difficulties leading to the institutionalization. It would be also beneficial to study what kind of difficulties follow each other in order to deploy the right technology that could be easily upgraded to meet new difficulties.

It can be stated that enhanced communications such as two-way videoconferencing through Internet or remote controlled webcams are the most cost effective solution available right now. This could help in loneliness and safety of the elderly. Information robot and home automation are the next step. With these many difficulties could be solved, but hardware and installations costs are remarkable. Also costs to develop reliable commercial applications would be high, but on the other hand there are numerous potential customers to divide the costs.

With today’s technology manipulation robots are very expensive and limited in operations and applications. They are best suited for disabled people, who have some specific difficulty, where simple robot can be effective. Also young disabled people are usually more capable in controlling complex robots directly. Thus, higher functionality for the robots can be achieved. Latest advances in humanoid robots are building a good platform for future’s autonomous applications, but there is a long way to go, even after the mechanical challenges are concurred in the near future. The ultimate benefit of a humanoid robot is that it fits well into environments built for humans with stairs, tools, handles etc.

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