# Scenario Development for Successful Aeging with Robot Companions

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Keywords: Healthcare Robots, Independent Living, Active Aging, User-Centered Design, Scenario Development.

Abstract: To illustrate how service-robots for healthcare can support independent living of older people three normative, narrative scenarios were systematically developed. In the sense of a user-centered design, scenarios are a promising opportunity to involve the target groups in the development and implementation process. Each scenario illustrates a different but typical day of an elderly person living with such a robot. Scenarios intend to encourage a lively but focused discussion of future technologies with different target groups. The personas (hypothetical but concrete prototypes of user groups describing specific requirements and usage behavior) were derived from the state-of-the-art concerning the every-day life of older people and the results of a qualitative interview-study focused on the structures and schedules of the seniors' daily routines. Additionally, key dimensions of the scenario space (specification of service-robots, older people and living environments) as well as descriptors characterizing each dimension, were identified by means of an exhaustive, systematic literature review and consistency analysis. The paper presents the scenario development process, the scenarios and their use in evaluation studies.

## 1 INTRODUCTION

Assistive service-robots offer some potential to meet occurring challenges in health care caused by severe demographic changes (Robinson, MacDonald and Broadbent, 2014). Robots assisting older people to manage their everyday life need to perform a variety of tasks, interact flexibly, and adapt to a wide range of capabilities and health constraints in non-standard situations and environments (Decker, 2012).

In contrast to the stereotype that older users are afraid of or hostile towards technology, they are willing to accept, creatively adapt and integrate the use of robots in their daily lives if the robot's benefits are clearly recognizable, and ensure an elongated independent life for the older people.

Service-robots for healthcare will be successful, if requirements, needs and capabilities of older users are carefully taken into consideration during the development process (Melenhorst, 2002). Aging is a very heterogeneous process. Requirements, resources and daily living differ a lot. It is crucial to encompass this diversity. „Robots may need to be specifically tailored to people who may be skeptical of robot use or reluctant to use them because of the great jump in technology the robot represents" (Robinson et al., 2014, p.576).

Although previous research has addressed seniors' acceptance of service robots, studies that focus on autonomously operating robots in seniors' homes and their long-term use in everyday life are lacking. Foremost this is due to limited practical experiences with robots – currently there are only very few robots available for long-term use in private homes (Robinson et al., 2014).

The paper presents the systematic development of three normative, narrative scenarios envisioning everyday life of older people living with a companion-type service-robots providing healthcare. Uses of these scenarios in future evaluation studies with different target groups are discussed.

## 2 RELATED WORK

Robots offer various possibilities to enable older people to live independently and improve their quality of life (e.g. Robinson et al., 2014). Compared to computers, tablets or TVs robots provide psycho-social and instrumental advantages due to embodiment, anthropomorphism and mobility: Robots can act as activating, autonomous, mobile interfaces in a smart-home environment, integrating various communication services. Thus, robots offer new opportunities and risks for health, social participation and interpersonal communication

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(Torta et al., 2014). Robots may be able to compensate older people's declining cognitive performances, motivate and activate or reduce fears that result from health problems, e.g. frailty and falling (Robinson et al., 2014).

Research considering the acceptance of robots assisting older people in everyday life yields valuable information concerning the design of robots and factors influencing human-robot interaction (Robinson et al., 2014). Theoretical models (particularly TAM, UTAUT, ALMERE) include factors like the complexity of technology, problem solving competences of users and self-efficacy in competence to use, perceived usefulness, perceived ease of use, joy of use, or trust (Robinson et al., 2014). These criteria are influenced by appearance, personality, appropriate social and emotional behavior of a robot as well as its adaptability, individuality and safe and robust functionality.
Older people are looking for robots that match their aesthetic desires, compensate age-related limitations and support their functional needs, are a saving of time and effort, complete undesirable tasks or complete tasks at a high level of performance (e.g. Beer et al., 2012).

Nevertheless, older peoples' perception of what to expect from a companion-type service-robot assisting them in their daily routines is limited due to the lack of experiences (e.g. Broekens, Heerink and Rosendal, 2009).

The usability and the acceptance of healthcare robots are often evaluated at a point, when the robot has already been developed. In contrast, the theory of social constructivism (Frennert and Östlund, 2014) emphasize that technology is socially constructed. It is expected that older people will adapt to robots individually which retroacts on the design of the technological device.

These theoretical approaches highlight the general dilemma of technology development: at the early stages of the developmental processes the effects and consequences of the use of the technology for its potential users are difficult to be estimated. The holistic idea to share life with a robotic companion is hardly conveyable. In late stages of the process, consequences appear clearer, the necessity to adjust requirements might occur, but it is almost impossible or at least expensive and time consuming to change the trajectory of development. (Kok, van Vliet, Bärlund, Dubel and Sendzimir, 2011).

One solution in this situation is scenario development (Kok et al., 2011). The aim of developing future scenarios is to understand and envision possible futures, enable, anticipate and structure the discussion of thinkable future situations, and point out alternatives and thus logical consistent opportunities for technology development regarding various insecurities (Breuer, Grabowski and Arnold, 2011). Scenarios are especially useful to involve different target groups of a future technology (e.g. older people, their family members, professional caretakers) in early stages of technology development.

# 3 RESEARCH QUESTION

The aim of this study is to develop future scenarios in order to provide a systematic illustration of complex questions related to the future:

a) How is it possible to enable successful aging when older people live with a robotic companion? Which robot functionalities are especially useful for different target groups in their respective home environments?
b) How can the robotic companion be integrated into everyday life in the most profitable way possible for all parties involved? When and how should the robot pro-actively intervene in different daily routines?

# 4 METHODOLOGY

Scenario development is a mixed methods approach. The methodological approach combines knowledge from various disciplines, including analytical and descriptive paradigms of traditional science as well as communicative and participatory approaches (Breuer et al., 2011).

Scenarios describe hypothetical, but plausible visions of the future. Scenarios do not intend to predict the future, but to illustrate thinkable future possibilities for the future, present alternatives, logical, and consistent opportunities of technology development. Additionally they apply, enable and structure discussions (Breuer et al., 2011).

A scenario is a sketched but concrete, consistent, (mostly) qualitative, and detailed presentation of a future situation, embedded in a specific environment. Scenarios consist of multiple dimensions. Each dimension involves various key factors and relevant trends (Breuer et al., 2011).

## 4.1 Normative, Narrative Scenarios

There are different types of scenarios. In the present

study three normative, narrative scenarios were developed. Each scenario specifies different but typical needs and requirements of older people living at home (Gaßner and Steinmüller, 2004).

A normative, narrative scenario is foremost used to establish a link between technology forecast and a realistic social context. Value-orientations as well as the intricacies of everyday behavior are explicitly taken into account (Gaßner and Steinmüller, 2004).

Normative scenarios describe an anticipated, preferable, visionary future without transgressing the realm of the possible (Bishop et al., 2007).

Narrative scenarios portray the future "[…] in the way a science fiction story does – with human protagonists and a rudimentary plot" (Gaßner and Steinmüller, 2004, p. 31). Basically a narrative scenario is a short story of a lived-in daily experience of older people living with a companion-type service-robot (Kok et al., 2011).

### 4.2 Process of Scenario Development

The systematic development of normative, narrative scenarios is a rigorous process that involves logical, detailed steps (Breuer et al., 2011). Based on an inductive process, conclusive stories are derived from associations of distinct interactional patterns and reciprocal influences of the descriptors characterizing the scenario space which determine the future situation (van Notten, 2005). Before writing the storyline of the scenario, the scenario field has to be analyzed.

During this process the key dimensions and characterizing descriptors are identified. Systematic literature review led to an aggregation of descriptors and contribution of information sources. Therefore, literature was content analysed regarding the category of the identified technology (robot, smart home, enabling technology), its state of development (commercially available, prototype, future trend), its acceptance, and (dis-)advantages of usage. Based on that, descriptors are identified and filtered regarding their impact (high, low, or no impact) on the scenario (Breuer et al., 2011).

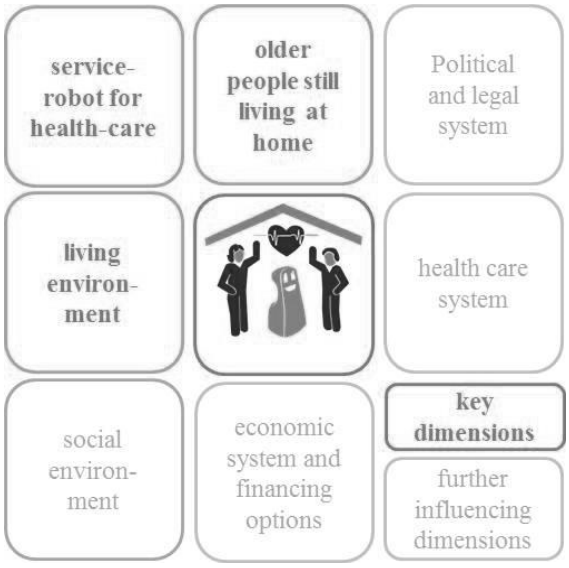



Figure 1: Dimensions determining scenario space.

Afterwards, descriptors are validated by assessing their consistency to reveal the ones with high influence on the scenario space (cross-impact-analysis): Each descriptor is paired with a second one. The pair is evaluated regarding the question if one descriptor is totally inconsistent, neutral, or supporting the incidence of the second descriptor (Porter, Roper, Mason, Rossini and Banks, 1991). Further, consistent descriptor-bundles are determined based on an assessment of the consistency.



## 5 SCENARIO SPACE

The scenario space encompasses the employment of a companion-type service-robot that provides healthcare functions for older people still living in their private homes in order to elongate independent living, increase well-being, promote health, and assist with tasks of everyday living.

## 6 KEY DIMENSIONS AND DESCRIPTORS

Key dimensions and descriptors were obtained regarding two main issues: 1) the technological process, i.e. the ongoing increases in the development of assistive service-robots for healthcare and 2) the impact of the customer, i.e. the involvement and integration of older people in the upcoming development of these robotic assistants (Breuer et al., 2011).

Three key dimensions could be identified: the technological opportunities of service-robots, special requirements and needs of older people using such a robot, and the living environment of the user (figure 1). The subsequent sections summarize the final characterization of the key dimensions after their validation and consistency check of the identified descriptors. Further dimensions influencing the scenario space were analyzed as well (social

environment, political and legal system, health-care system, economic system/financing options). Due to the limited space available a detailed presentation is waived in this paper.

## 6.1 Specification of Living Environment

Manifold technologies are available supporting older people to retain independence in their private homes. Smart home technologies provide promising devices. Table 1 summarizes the specification of the descriptors defining the future living environment of older people.

Table 1: Characterization of descriptors defining the key dimension "living environment".

| descriptor | characteristics |
|---|---|
| outline of apartment | Apartments are barrier-free, providing enough room and without stairs or door sills. |
| (technical) equipment in apartment | Apartments are smart home environments, equipped with smart electronics to control windows, doors, lightning, air conditioning etc., a smart fridge as well as an alarm system detecting fire, gas or theft. |
| in-house infrastructure | Wifi is available. Exchange and synchronization of relevant information between the various smart home devices is possible. |

## 6.2 Specification of Service-Robots

Though a large variety of service-robots is available already, most of those devices offer only single functions or support for a certain functional area. For holistic support, service robots need to be multifunctional (Frennert and Östlund, 2014). Besides, as mentioned in section 2 (Related Work) manifold factors influence the acceptance of

Table 2: Characterization of descriptors defining the key dimension "robot".

| descriptor | characteristics |
|---|---|
| mobility | Robot can navigate autonomously. |
| connectivity | The robot is connected to smart home devices via Wifi. |
| tools to perceive environment | The robot is equipped with various sensors enabling orientation, and detecting and distinguishing people. |
| tools to manipulate environment | Instruments to measure and monitor vital signs are available. The robot is equipped with a tablet and drawer for transportation and storage. |

Table 2: Characterization of descriptors defining the key dimension "robot" (cont.).

| descriptor | characteristics |
|---|---|
| tools for communi-cation | There are tools integrated for verbal communication (speech recognition and synthesis), nonverbal communication (gesture recognition, touch recognition, animated eyes) or paraverbal communication (e.g. acoustic signals for warning), as well as a touchable screen and a remote control. |
| appearance | The robot is of 1.20 m height, with a friendly, animated face. Its color can be chosen due to aesthetic desires. |
| personality | The robot is a friendly, intelligent, teachable, helpful, and extrovert companion. |
| behavior | The robot is able to behave socially and emotionally appropriate. |
| applications provided for user | According to requirements, needs, interests and preferences of the user, applications, can be executed. The applications encompass security issues, health-support (e.g. monitoring vital signs, cognitive and physical training, medication management), support to structure daily living, information services, support of social communication and inclusion, and entertainment. |

service-robots. A robot providing positive resource balance, high level of individuality, and support of values of personal identity, dignity and independence might be accepted by older people (Robinson et al., 2014).

Table 2 summarizes the characterization of descriptors defining a future service-robot for healthcare for older people who live independently in their own apartments.

## 6.3 Specification of Older People

A lack of attention to user needs may be one factor that explains the limited adoption of many aging-related technologies. The robotic device needs to adapt to the individuals' requirements, habits and preferences of older people and fit to their everyday lives (Ballegaar, Hansen and Kyng, 2008). It is important to consider the users' current level of needs (e.g. Beer et al., 2012).

Although the group of older people is very heterogeneous some abilities improve or stay the same with age, and others decline, because of a natural aging process (Ackerman, 2008). There are typical constraints, that affect most older people at a certain age: changes in life-style leading to the loss of healthy habits, diabetes and obesity, that need

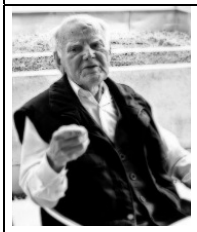
particular attention to dietary habits, mild cognitive decline and memory difficulties, or vision and manipulation difficulties, creating barriers to using technology (Marcellini, 2012).

The social science provide a rich body of literature about how older people compensate the change and loss of competences and resources and deliver insights on understanding the role of objects and environments, activities that the elderly are confronted with on a daily basis (Forlizzi, DiSalvo and Gemperle, 2004). In general, daily living of older people is structured by habits and routines, mainly consisting of activities like sleeping, eating, personal hygiene or housekeeping. Half of everyday activities are performed at the same place and time. Due to individual differences regarding needs, financial or social constraints, lifestyle or goals in life (Lim et al., 2012), individual interests, abilities, skills and experiences (Frennert and Östlund, 2014), timing and content of daily activities are quiet heterogeneous (Lim et al., 2012).

Currently, only a limited amount of information is available about the typical structure of older people's daily routines (Richter and Döring, 2013). Therefore an explorative, qualitative study was conducted. A theoretical sample of 12 seniors (7 women, 5 men aged 61 to 85 years; different health and relationship states, competences, lifestyles and experiences) were interviewed. The problem-focused semi-structured interviews were focused on the structure of everyday life and opportunities to integrate a robot in that schedule. The interviews were recorded and fully transcribed and analyzed using established content analyzes methods (Richter and Döring, 2013).

Based on the state of the art and the findings of the interview-study, five personas were derived. A persona is a hypothetical, fictive user, representing a prototypical group of users with their distinctive characteristics and usage behaviors (Mulder and Yaar, 2007). Table 3 gives a brief summary of the three personas that vary most, and are therefore defining the specification of older people regarding the developed scenarios.

Table 3: Personas.

| | |
|---|---|
|  (source of image: Rainer Sturm/ pixelio.de) | Elfriede, aged 73, lives alone in a 2-room-appartment after her husband passed away 4 years ago. Most of the days she can handle her arthritis. The decreasing cognitive abilities are more disturbing for her. She is enterprising, and loves baking cakes for friends and family. A typical week is structured by several fixed appointments, particularly to cultivate her many social contacts. |
|  (source of image: Rainer Sturm/ pixelio.de) | Wilhelm, aged 63, divorced, and living alone in his house. He is living a healthy and sporty lifestyle, structuring his days according to his personal training plans. Furthermore, he enjoys flexible, spontaneous activities. Although he is integrated in a solid social network, his friends and family are afraid he might get lonely. |
|  (source of image: Moni Stertel / pixelio.de) | Horst, aged 93, is living in a 3-room-apartment with Hildegard. Horst's cognitive abilities are restricted due to dementia. Moreover, both are suffering from various severe health restrictions resulting in limited mobility, harsh medication and a strictly regulated day. Regarding personal hygiene, housekeeping and cooking they need support. Nevertheless, Horst is merrily happy, enjoying each day. |

# 7 SCENARIOS

The three normative, narrative scenarios describe exemplary but concrete use cases. Each scenario is based on one of the three personas (section 5.3). The scenarios are designed in the form of a detailed calendar entry of a complete day. The activity descriptions are written in the style of a personal diary describing how each persona experiences life with the individually tailored service-robot. In addition to the calendar-typed diary, a picture and a brief summary illustrating the core information concerning the personas' requirements, their reason for using a robot and the robots' essential functionalities, are presented. The following paragraphs present the three scenarios.

## 7.1 „With Se-B, a Truly Supportive Companion, I Feel Safe and Protected."

Elfriede has been living with Se-B (Robotic Security Buddy) her protective robot-friend for some years.

Figure 2: Elfriede baking a cake proposed by Se-B (authors' illustration).

Table 4: Extract of a typical day at Elfriede and Se-B.

| | |
|---|---|
| 7:00 | Se-B gently wakes up Elfriede. The robot asks if she feels well while checking her vital signs. Yesterday Se-B had to call an emergency because she felt to the floor. |
| 7:20 | While Elfriede takes a shower, Se-B prepares the kitchen table for breakfast. |
| 8:00 | Se-B reminds Elfriede to take her medicine and informs about her appointment with her doctor at 9:30, including an advices which bus to take, and what Elfriede needs to bring with her. |
| 8:55 | Elfriede prepares herself for leaving the house. Se.B informs her that all windows are closed, reminds her to take the keys and tells her farewell: "Call me, if you need help." As soon as the door is closed, the robot activates the security systems, and installs itself at the charging station. |
| 11:00 | Se-B heartily welcomes Elfriede back home. |
| 11:15 | Guests are announced for the afternoon; Se-B automatically proposes a wholesome cake-recipe, including a checklist for preparation and compiles a custom-tailored shopping list. |
| 19:30 | It's time for the online English course. Se-B assists her logging into the virtual class-room. |
| 20:15 | Instead of training the new vocabulary with the robot (as usual), Elfriede decides to meet her fellows in a virtual bar for a little chat. |
| 22:00 | Elfriede informs Se-B that she goes to sleep. That's the signal for the robot to check the apartment, lock the front door, activate the security system, and to leave to its charging station. |

Because of increasing health problems she decided to install the robot, instead of moving into an assisted living facility. Meanwhile, Se-B is fully integrated in her everyday life, assisting her with organizing her schedule, reminding her of her medication, keeping her company, keeping her active and supporting her with her favorite pastime: baking. Since she got accustomed to Se-B's presence, she feels more confident and safe.

Due to limited space, only an extract of the diary envisioning the daily schedule of Elfriede and Se-B (table 4) can be presented. For the following two scenarios, dairies had to be summarized.

## 7.2 "Pe.T.Ro. Is Motivating Me to Stay Active and Open-Minded."

Wilhelm retired one year ago. Since that time his family and friends regularly complain that he spends too much time alone. They are worried, he might get lonely. Wilhelm does not share these concerns. He just uses every minute to train for a marathon. To calm his nanny friends down, he agreed to install Pe.T.Ro (Personal Training Robot). Meanwhile, he is fond of the companion-type robot, supporting him to optimize his training. Pe.T.Ro., acquainted him to online-dating which enables Wilhelm to get to know women without being observed by his overprotective friends.

Figure 3: Wilhelm doing stretching exercises after a running, instructed by Pe.T.Ro (authors' illustration).

Typically Wilhelm gets up at 7:30 a.m., to consult Pe.T.Ro., about the best track for his training run according to condition, weather and training goal. After Wilhelm is done with his training, he takes a shower and has breakfast while Pe.T.Ro. analyzes his training data, checks the calendar for appointments and co-ordinates further activities for the day.

## 7.3 "Ca.R.L. Is Our Window to the World."

Horst is aware of his bad health conditions but does not complain about them. Basically, he is happy: his

beloved partner Hildegard and Ca.R.L. (Robot to CAre for and Regulate Life) the sensitive, reliable assistant lighting up his days. Last year, when his son recommended to install Ca.R.L., Horst was afraid that the robot would be too complex to handle. What convinced him was that the only alternative solution would have been to move to residential care. After a short probationary period, Horst could not imagine to spend his days without the new roommate any more.

Figure 4: Horst and Hildegard using video-telephony (authors' illustration).

Horst and Hildegard are accompanied by Ca.R.L. throughout the day. The robot organizes their schedule, reminds in time and considers their current condition. The most enjoyable time of the day is when the two drink a cup of tea in the afternoon while chatting with their family via video-telephony – that is almost like sitting around the table together. Yesterday, Horst even sent Ca.R.L. to the bathroom while chatting with his grandson. That way he could have a look at the broken lights to make sure he brings the right type of bulbs for change.

# 8 CONCLUSIONS / DISCUSSION

The presented normative, narrative scenarios cover three different visions of older people living with a robotic companion supporting their everyday life. According to varying requirements, resources and preferences, the service-robot takes over in different roles with a set of individually tailored functionalities.

Though normative, narrative scenarios do not rely on controlled, repeatable, falsifiable experiments, the development is based on scientific, traceable, and transparent principles (Kok et al., 2011). Scenarios are determined by the quality of data and information incorporated, internal consistency, plausibility, and the appropriateness and realizability of the presented situation (Porter et al., 1991). However, no scenario can predict future situations for sure (Porter et al., 1991). A future scenario is always debatable for it cannot address all the different perspectives and opinions of scenario creators and addressees (Gaßner and Steinmüller, 2004).

Indeed, scenarios intend to encourage a lively but focused discourse about a specific issue and – in the sense of a user-centered-design approach – incorporate the target groups into the developmental process in a very early stage. "Ideally, scenarios lead to spontaneous, often emotional exchange of opinions about the presented subject (Gaßner and Steinmüller, 2004). Engaging robots to support older people's daily living is not just a question of technological opportunities. There are concerns regarding a potential loss of privacy, or the risks of isolation or dehumanization of care. It's not fully clear if robots really can be supportive rather disruptive, how such robots can be financed, how healthcare services have to change, or what happens in case a robot causes damage. Those aspects have to be discussed. Assistive service-robots are one potential solution to meet the challenges caused by demographic change – but is it the most promising one?

The next step will be to present the three normative, narrative scenarios to experts (e.g. politicians engaged with issues of the healthcare system, technology developers, or caregivers) and non-professionals (e.g. older people, or family-members providing care) belonging to the field of the scenario space. The discussion about the scenarios will be guided by means of semi-structured interviews. The detailed discussion of the robot scenarios with members of different target groups and experts as part of an evaluation study promises to generate both insights in the acceptance of companion robots for older people as well as new ideas for robot design.

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