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Robots for Elderly Care Institutions: How They May Affect Elderly Care

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Abstract. “Welfare robots” are supposed to help maintain the quality of elderly care in institutions, while a dramatic demographic shift will lead to a significant problem attracting a sufficient number of caregivers. We give a status on the state of the art of welfare robots with a focus on the technical challenges that will constrain the development of robots in the next two decades. From this it follows, that robots will be recognizable as machines in the near future. To stay in concrete grounds, we will describe three use cases that are currently addressed in a project in which we design robots that will be applied in elderly care centers. These serve as examples of the kind of welfare robots that could realistically built in the near future. In the last section, we discuss the role such robots could take and how they could change elderly care in the near future.

Keywords. Welfare robots, social role of robots, elderly care

1. Introduction

There exist expectations that robots will play an important role in addressing problems in elderly care connected to the so called ”demographic challenge”: Through the demographic development, there will be more elderly people requiring care and less people available for giving care [1]. Experts in elderly care management agree, that the way of operating elderly care facilities requires changes because of an already now existing but in the future increasingly dramatic lack of ”warm hands” e.g. care-caregivers. The hope is that this demographic shift can be compensated for by technology. In 2004 Rastegar [2] points to an, at that time, ongoing process of industrialization of health care, the health care system was undergoing changes in the organization of work, like how other industries did centuries ago. This process was characterized by an increasing division of labor, standardizing the work, managerial superstructure, and the degradation (or de-skilling) of work. This industrialization is ratified in today’s health care system and we now face the next level of industrialization which is the ”automation of elderly care”, where the replacement of warm hands through robots are manifest.

There also exist high and partly unrealistic conceptions about the state of the art of robotics: In the media we see visions of humanoid robots that look and act similar to, sometimes even indistinguishable from, humans: In some vision, robots are even seen on an equal footing with human partners, replacing all problems that make human relation- ships interesting but also sometimes challenging [3].

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(a) Laundry and garbage handling (b) Guidance (c) Water delivery

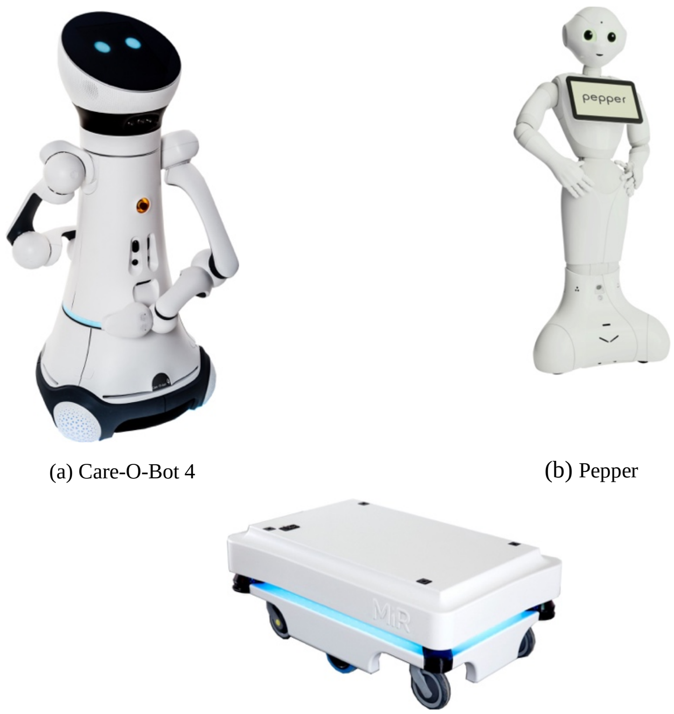
Figure 1. The three cases of the SMOOTH project (all illustrations made by the Danish Technological Institute)

In this article, we intend to give a more realistic picture on how robots in elderly care might look like and what roles they will be playing. To stay on reasonable grounds, we will look at a time span of two decades. Technological development is too unpredictable to make serious statements beyond that time window. Our central thesis is, that these robots will be machines and will be recognizable as those.

The reason for that (as it will be detailed in section 2), despite all progress that has been made in the last decades, is the technological challenges that today's robotics face. Engineers and researchers are still not able to design human like perception and behaviors on robots. Therefore, robots will not be able to substitute human care-givers in the near future, which also is not desirable in any case.

How robots in elderly care might look like in the next two decades will be discussed in section 3. To stay on sufficiently concrete grounds, we will discuss robots that are currently being researched on in the SMOOTH project (Seamless huMan-robot interactiOn fOr THe support of elderly people, smooth-robot.dk [4]). The SMOOTH project aims at developing robots to be used in elderly care centers, targeting a market entry in 2022. These robots are supposed to facilitate the work of care-givers as well as to improve the quality of life of elderly people. In a participatory design process, three use-cases have been developed. In one of them, the robot will assist the staff in managing laundry and garbage (see figure 1a). In two other contexts, these robots will be interacting with elderly people: In the second use case, the robots will guide the elderly people from one place to another, as illustrated in figure 1b. As an extension of this use case, the robot could also just walk together with a resident for increasing his/her activity level. In the third use case, fluids are served to elderly people and by that, residents will also be reminded and motivated to drink enough (figure 1c.)

The development of welfare robots should be guided by ethical considerations about how we want to develop our society as a whole, being aware that elderly people are one of the weakest and most fragile members. To facilitate the acceptance of robots by the staff of elderly care institutions as well as their residents, it is also required to design the appearance and behavior of the robots in an appropriate way ensuring the dignity of the humans interacting with the robot. For that it is important to be aware of the expectations and capabilities of the residents. The (social) role, robots in elderly care could take as well as how this might change elderly care in the future, will be discussed in section 4.



(a) Care-O-Bot 4

(b) Pepper

(c) The MiR100

Figure 2. Robotic solutions for the health care system. Permission to use the figures are given by (a) Fraunhofer Institute, (b) Softbank Robotics and, (c) Mobile Industrial Robots

2. Technical Aspects of Welfare Robot Development

In industry, robots have been utilized for decades. However only recently industrial robots, i.e. collaborative robots, and humans start to share the environment rather than being separated by a fence and collaborate on tasks [5]. Also, various mobile solutions, e.g MiR [6] (see figure 2c) or GoPal[2], designed for performing logistic tasks in an environ- ment shared with humans, have been introduced. In parallel, robot technology is also being introduced in other domains, such as telepresence robots [7] tailored to health-care applications, business communication or private people.

In addition, there exist more complex welfare robots which even can be equipped with arms such as the Care-o-Bot [8] (see figure 2a). While applications that do not require an arm, such as guiding people in large stores, are already operating on a high technical readiness level [9], applications making use of the arm are still in a laboratory phase. Another type of robots also equipped with arms is the Pepper robot [10] (see figure 2b), which is used in applications such as welcoming, informing, and amusing customers. Here the arms are used only for gestures supporting verbal expressions.

The availability of solutions at a high technical readiness level was facilitated by a couple of important milestones being achieved: with the introduction of Microsoft's Kinect camera in 2010, an affordable 3D sensor facilitating efficient scene analysis,

[2] http://www.robotize.com/, accessed:22-6-2018.

crucial for robot interacting with their environment, was introduced and quickly adopted by the robotic community [11]; human aware navigation, in particular in indoor environments, has been solved to a level where mature solutions are commonly available [12]. Recently, with the increase of computational power, in particular graphics card applicable for parallel calculations, deep neural networks have gained attention [13]. While their impact on robotic applications is still limited, deep neural networks have demonstrated real-time detection of objects [14] on much higher performance levels than be- fore. Although neural networks nowadays even outperform humans on selected recognition tasks, artificial intelligence is not expected to outperform human manipulation and reasoning in the near future as stated by Christensen et al. [15, p. 6]:

> We might be able to design neural networks to learn the correct features to beat the world champion at Go, but that same neural network cannot beat a 5 year old at tic-tac-toe.

These problems in developing more complex welfare robots are connected with technical challenges in at least six areas:

- **Design of a human-like skin:** There is no technical match for the magnificent skin encompassing a variety of tactile sensors humans (and animals) have. However, this is required for complex manipulation.
- **Design of human-like hands:** We are far away from building hands with the complexity of human hands. The hands of robots that are used today in real applications are clumsy and the more sophisticated hands in labs are not robust and still far away from the dexterity of human hands.
- **Manipulation of objects:** Even if we had artificial hands comparable to human hands with sophisticated skins, we would still need to design a control of these hands, that would allow for a manipulation of objects as humans are able to perform. For humans, this takes years in child development and the learning mechanisms are not understood.
- **Moving on legs:** While there has been significant progress on walking robots, like the Atlas from Boston Dynamics [16], there is still a long way to design stable walking behaviors when movement and manipulation are combined or interactions with other agents take place. Also, a fall of a robot in, e.g., an elderly care home, is something that should be under any circumstances avoided. Hence, we predict that in the next two decades, robots in public spaces will primarily move on wheels.
- **Cognitive control:** While a substantial amount of research on reasoning and knowledge representation has been done (see e.g. [17]), performing high-level reasoning based on real world sensor data is still a challenge today. This, as well as challenges in the hardware development mentioned above, accounts for the lack of applicable solutions on mobile manipulation which is expected to call for a least a decade of research [18]. This also implies that robots typically cannot substitute humans since they by nature are mobile and manipulate their environment.
- **Design of appropriate Human-Robot-Interaction:** The interaction between humans is built on a well-functioning speech and object recognition, as well as other sensors such as smell and taste, and finally also tactile sensing. While there has been significant progress in speech and object recognition, today's systems can still only be used in rather controlled environments when a high degree of performance is required.

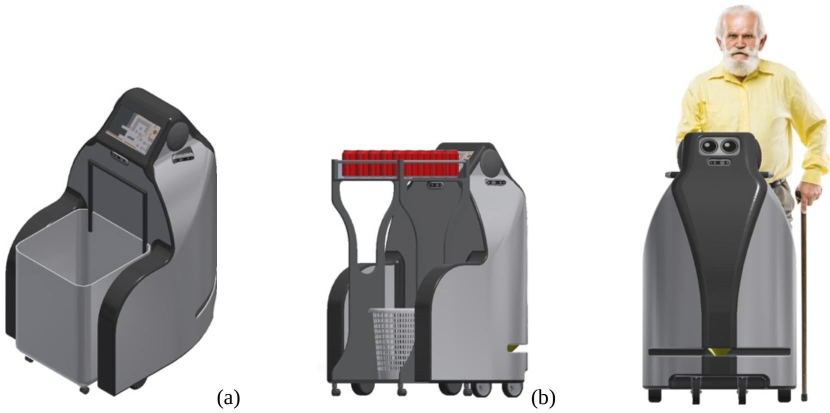
Because of these challenges, the robots we will see in care-facilities in the next two decades will most likely be machines on wheels. These machines will navigate in the environment of humans while also communicating and collaborating with humans. The machines will operate alongside humans performing repetitive tasks and by that re- lease the necessary resources for more and better care. However, the tasks they perform will involve an increasing number of free parameters, such that the robot adapts to variations in the tasks. In contrast to industrial robotics, grasping and manipulation is much more complex in general scenarios. In elderly care institutions the environment changes frequently and objects are very different. We believe that to be technically and commercially feasible for the next decades, it is unrealistic that welfare robots will have complex manipulators connected to robotic arms. However, less dexterous devices to manipulate the environment might be usable for specific tasks.

3. Robots in Elderly Care

From the challenges described in section 2 it follows that robots in elderly care hardly will be recognized as being human-like. They would fail to solve "simple tasks" such as handing over a cup of tea. They will with high likelihood move on wheels and will not be able to deal with unexpected situations. Hence, they will be clearly recognizable as machines. Consequently, we should probably not try to trigger a humanoid perception since this could end in disappointment.

The limits of what is technologically possible will also put demands on welfare robots cost-efficiency since a care-giver could not be directly replaced by a robot. It is therefore an important and non-trivial task to find appropriate use cases. Here repetitive tasks such as guiding, serving water and logistics are good candidates. To ensure cost-efficiency, it will be important that these robots—despite their limited capabilities—are able to solve a variety of use cases. In the design conceptualization we had four main objectives the design had to accomplish:

- **Affordability** was facilitated through an economic distribution of sensors and general hardware. The design was kept simple and mechanisms of the robot have limited complexity.
- **Modularity** accord with affordability, it creates a far stronger business case if modularity is facilitated through the design. This was done by the robot having interchangeable attachments, that can be changed depending on the use case.
- **Simplicity** means that it should be clear to the care-giver and care-taker what the robot can and will do, how and where to interact with it.
- **Acceptability** accord with simplicity. Ease of use as well as the physical attributes of the robot play a role in whether users accept it into their work flow. It is important that the robots design allows it to convey its intentions as well as its internal state, while in no way facilitating misuse of the robot.



(a) (b) (c)

Figure 3. The SMOOTH robot. (a) and (b) show different modules for the logistic and drink serving use cases and (c) illustrates the robot being applied to the guidance use case.

Especially simplicity and acceptability play a key role in robot ethics. To avoid feelings of misunderstanding and human submissive behavior towards a robot, it should be clear to the user what the robot intends to do, how and when. The robot's embodiment, physical attributes and the way it interacts and manipulates in our environment, provide clues about this. Combined, with an intuitive user interface the robot can convey its intentions as well as its internal state, and by that ensure proper use of the robot while ensuring the dignity of the user.

The embodiment of a robot also provokes a kind of recognition where humans give a robot, with a human-like embodiment, human-like traits. This combination contributes to whether, or to what degree, the robot ”takes” a social role in a given situation.

On figure 3, the design concept of the SMOOTH robot is presented. Figure 3a and 3b show possible attachments for the laundry and drink use cases. The bin has a handle and wheels, which makes it easy to push around manually when not attached to the robot. The rolling serving tray is one possible attachment for the serving drinks use case. The guiding process is illustrated on figure 3c, with information displayed to the user via. a screen on the rear side of the robot.

Welfare robot should also be able to predict human reactions and actions, this can be done by taking body language and interaction patterns into account as much as it is possible with current state of the art technology. Essentially, the human perception of a welfare robot is shaped by its behaviors and physical design. In our view, it is crucial that welfare robots can anticipate human actions and pro-actively act on these, to arrive at smooth and hereby acceptable behaviors. For this, in the SMOOTH project, we plan to use an adaptable state space transition model that exploits regularities in interaction patterns.

4. How Will This Change Elderly Care?

As outlined in section 3, it is evident that robots will—in the near future—not take away ”warm hands”. Many tasks that care personal performs today cannot be performed by robots, due to the technological challenges outlined in section 2. The robots will not have complex hands for manipulation, probably they will operate on wheels and the interaction with these robots will characterize them as machines. Hence an ”automation of elderly care” is neither possible within the next 20 years, nor is it desirable.

To avoid frustrations of human’s expectations to the robot, the SMOOTH robot has been designed to minimize human-like associations, e.g., by avoiding the use of facial expressions and minimize the use of anthropomorphic features. The goal for this is to design a robot which is recognizable as a machine. In the three use cases developed in the SMOOTH project (see figure 1), the robots act as an entity that provides services. Hence it should be perceived by the staff and residents as a tool and not as an equivalent to a human care giver. However, there exists a gray area in-between ”tool” and ”a care giving agent” and we need to identify which expectations, intentions, and human-like associations are made towards the robot.

It will be decisive that the SMOOTH robot is able to precisely and accurately, through its appearance (combined with signals), convey its capabilities such that humans in its surroundings easily can interpret and respond to it. The physical appearance of the robot is designed simple and elementary with only few anthropo-morphic features that can facilitate the transparency of the robot’s capabilities (and lack thereof) to humans. Combined with this, the robot will be interacting with humans and assist them in various tasks, therefore social attributes or social cues are a key part of the SMOOTH robot’s functionality. However, this will be facilitated by the robot creating dialogue and through the movement and proactive behavior of the robot rather than via excessive use of non-verbal cues.

Breazel [19] explains how social robots designed for health care that uses non-verbal cues make the interacting human subconsciously interpret, form social judgments, and respond to robots as they would do when the cues were performed by people. The humans interacting with these robots have their social judgments of things like trustworthiness and persuasiveness impacted when the robot’s non-verbal cues are adjusted. This makes the robot able to, at different degrees, deceive and manipulate humans to a perception of the robot which is in fact false. When we introduce robots to care facilities, it is of paramount importance that it won’t lead to deterioration of care. This can happen when the elderly loose human contact and socialization when a robot takes over care- givers tasks. We will discuss how welfare robots in the form of social robots can have deteriorative implications when introduced to care facilities.

The robot used to form the discussion is the humanoid social robot Paro [20], which is a robotic seal designed to have therapeutic effects for elderly. The Paro [20] is a therapeutic tool that potentially has the ability to replace a care-giver in an intimate social interaction. The Paro’s use of non-verbal cues makes it deceive and emotionally manipulate elderly (especially with dementia or general cognitive decline), by showing high similarities with animal behavior and by the use of morphologies, to make them think it is real.

The intention of developing Paro has been to use it as a therapeutic tool, but if the use is not regulated properly it can have detrimental outcomes [21]. Robert Sparrow explains that there are several benefits of a robot like the Paro but the majority of these are predicated on the elderly mistaking, at a conscious or unconscious level, the robot for a real animal [22]. As we also outlined earlier here, the use of non-verbal cues has impacts on people’s social judgments, and in case of the Paro, it also gives an impression that it can interact and behave like a real animal which makes the therapeutic effect depend upon the degree of deception.

In contrast, the SMOOTH robot is a social robot with general purposes, designed to interact with humans and especially elderly in a socio-emotional fashion via. dialogue. The limited use of non-verbal cues combined with a non-identifiable design, i.e., non-animal or humanoid, makes us believe that the users will recognize the robot rather as a tool than a social agent while the success of the robot is not depending on how well the robot deceive its users. Hence, the SMOOTH robot should be understood as a tool for the care-receivers and care-givers and not as a replacement for the care-givers or a companion for care-receivers. However, in the SMOOTH project, we also face some of the same problems as discussed at the example of the Paro robot. In the following we will identify and explain these and discuss how we plan to address them.

A potential risk of replacing relationships is identified in the guiding use case. Although, at a first glimpse, one may not realize any concerns since we simply help the care-receiver to another location in the care facilities. However, tasks like this are offering the occasion to be with another person and trigger social interactions. A guiding process is used by the care-givers to administer empathetic touch, and to make small talk with the elderly. Therefore, leaving the guiding process to the robot could create a form of isolation and loss of human contact. This is important to realize, and we should use this knowledge and try to make up for the modification of care by playing music for the elderly and projecting images of things that they like, e.g., family photos and art or through dialogue and especially persuasive dialogue.

This, even though it is verbal cues (dialogue and persuasive dialogue), and therefore we do not face the same problems as with non-verbal cues outlined earlier, we still have ethical considerations. Persuasive dialogue is per se done with the intention, or at least with the result, of encouraging people to, in this case, follow the robot. This could potentially have the effect of deluding people about the nature of the robot, which can set the robot in a social role and shift it away from being perceived as a tool. Although the perception of the robot being a social actor are not our primary intention, it can happen during the everyday usage. One could argue, that having welfare robots being perceived as social actors are acceptable when it occurs naturally and not from overly use of deceiving and manipulating methods.

5. Conclusion and Future Work

Based on the recent technological development as well as still unsolved challenges we argued that robots, within the next two decades, cannot substitute care-giving staff but rather remain recognizable as machines. Robots can be utilized to support staff within the care facilities with well-defined tasks and handle smaller variations of these tasks. Given these limitations, robots are suggested to be designed with affordability, modularity, simplicity, and acceptability as central criteria to achieve technologically and commercially viable robotic solutions. For three specific use cases potential robotic solutions, that make use of social cues to support their function but are aimed not to be perceived as companion, have been outlined. For the development of future welfare robots, the identification of relevant use cases taking technological and commercial constraints into account as well as the appropriate design of the appearance and behavior of robots is an important and non-trivial task.

We have discussed how non-verbal cues can influence people's social judgment. The success of some social robots is based on the user having their social judgment and emotions manipulated by the robot. By using different degrees of non-verbal cues, the robot can deceive the users to a perception of the robot that is in fact false. These types of robots, meant to do good and have therapeutic effects, could be problematic for elderly care if not regulated properly.

We discuss how the SMOOTH robot is designed to be perceived as a machine, to minimize the user's expectations towards the robot and thereby make sure that the robot won't be perceived equivalent to a human caregiver. The SMOOTH robot will be able to, through its appearance, convey its capabilities in a way that humans can easily interpret and respond to creating smooth interactions, avoiding misunderstandings, and ensuring the dignity of the caregivers and elderly are kept intact. Besides these efforts, there are still ethical risks in the SMOOTH project. The use of persuasive dialogue can have manipulating effects encouraging the user to participate in interaction with the robot, that they might not have done on their own accord. This must be managed carefully to ensure natural human-robot interaction. We identify how the guidance use case has a potential risk of replacing relationships since tasks like these are often used as a medium for empathic touch. We give suggestions to how we plan to handle this by triggering, perhaps not similar, interactions between the user and the robot.

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