Integrative Social Robotics Hands-On

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Abstract

In this paper, we discuss the development of robot use cases in an elderly care facility in the context of exploring the method of *Integrative Social Robotics* (ISR) when used on top of a user-centered design approach. Integrative Social Robotics is a new proposal for how to generate responsible, i.e. culturally and ethically sustainable, social robotics applications. Starting point for the discussion are the five principles that characterize an ISR approach, which are discussed in application to the three use cases for robot support in a Danish elderly care facility developed within the SMOOTH project. The discussion by an interdisciplinary design team explores what attention to the five principles of ISR can offer for use case development. We report on the consequences of this short-time exposure to the basic ideas of ISR for use case development and discuss the value of approaching robot development from an ISR perspective.

1. Introduction

Much recent research has demonstrated that the development of robots needs to take the socio-cultural and societal contexts into account, in addition to aspects of robot functionality and usability (e.g. Sparrow & Sparrow, 2006; Sharkey & Sharkey, 2012; Arnold & Scheutz, 2017). A considerable problem is, however, that the discourse praxis of ethical and socio-cultural evaluation (in ethics councils and governmental thinktanks) on the one hand, and the praxis of research and development of (social) robotics applications on the other hand, are rarely integrated. More recently, robot design is often carried out in user-centered or even participatory approaches (see Lee et al., 2017), and ethnographic studies inform robot development projects about the kinds of workflows at those places where the robot is supposed to be used or the social environments in which it is placed (e.g. Forlizz,i 2007; Mutlu & Forlizzi, 2008; Chang et al., 2013; Šabanović et al., 2013). This serves to integrate the concerns of stakeholders into robot development. However, Forlizzi (2018), for instance, argues that user-centered design has to be reconceptualized radically in order to accommodate the broad range of stakeholders, many of whom are not users but may be affected by the robot developed in a multitude of different ways. Furthermore, especially concerning the broader societal discussion, robot development and representatives of sociological or philosophical perspectives often come together only in terms of ethical advisors and so-called 'outreach activities', such as public panels, contributions to fairs and exhibitions or media coverage. There are as yet no established practices that could define how the two can concretely inform each other (Lee et al., 2017). In order to ensure that social robotics applications indeed fit into our socio-cultural interaction space, philosopher Johanna Seibt has suggested that we need to consider the research, design, and development process in social robotics in new ways. The approach of "Integrative Social Robotics" (ISR), which is still under development but formulated in outline (Seibt, 2016, Seibt et al., 2018a), applies methods and analytical concepts from the Humanities to describing, informing and facilitating the process of robot design, development and placement continuously from beginning to end. Using a mixed methods approach that integrates the analytical concepts and methods of the Humanities, ISR aims to do justice both to the richness of socio-cultural interaction by taking into account the multitude of respects in which social partners may orient to each other, and to the social, societal, ethical, cultural and environmental factors that define the contexts in which a human-robot interaction is envisioned to take place. ISR has been developed as a new solution to the new ethical questions that cannot be addressed with older methods of user-driven or participatory designs. In ISR, value-theoretic considerations take centerstage—in fact, ISR prescribes that applications be *primarily* driven to preserve or enhance socio-cultural and ethical values and only secondarily by considerations of utility. However, ISR is also motivated by theoretical (ontological) considerations and requires that social robotics applications be produced in interdisciplinary developer teams, where the team members gradually come to share relevant intersections of technological and scientific idioms and thus acquire non-formalized transdisciplinary competences.

ISR suggests that social robotics applications be developed in *continuous collaboration* of fully interdisciplinary teams, which requires special expenditures both in terms of funding and organization. While some applications are currently being developed applying ISR in its full-scale version (www.integrativerobotics.org), the question arises whether it is also possible to implement ISR in a 'light' version. In other words, we may ask what the added value of implementing ISR as a set of guidelines and short-term interactions of experts is in a guided interdisciplinary dialogue (instead of as a new *praxis* of continuous cross-disciplinary team work throughout the research, design, and development process) for the use case development in a robot development project.

The current paper investigates this question by means of a case study. We set out with a brief introduction to the ISR approach. Focusing on the interdisciplinarity and context-sensitivity of the development of robot use cases, i.e. scenarios of use of robots, which address general needs and have the potential to become business cases, we present a study of applying the ISR approach in a 'light' version to the use case development in the SMOOTH project (Seamless huMan-robot interactiOn fOr THe support of elderly people, www.smooth-robot.dk) (see section 3). In section 4, we report on the results of the interdisciplinary dialogue, which was initiated during a conference workshop. In the follow-up discussion presented here, researchers from various disciplines reflect on the ISR method and consider from their disciplinary perspectives what the different principles of integrated social robotics may mean practically during the development of robot applications. In our discussion in section 5, we show that already the 'light' procedure we follow in this case study allows us to identify ways in which an integrated social robotics approach goes beyond a user-centered design approach. We explain how robot use case development can benefit from even short-term reflections of the envisaged goals and procedures through the lens of the five principles of integrated social robotics and draw additional lessons for the ISR approach.

2. Integrative Social Robotics

The approach of ISR (Seibt, 2016) was introduced in order to address a fundamental difficulty for current research and policy on social robotics, the so-called "triple gridlock of description, evaluation, and regulation" (Seibt et al., 2018a). In a nutshell, the triple gridlock comes about as follows. (i) Currently we lack a comprehensive, systematically integrated, and detailed theoretical understanding of human-robot interaction—a theoretical description of the cognitive 'mechanisms', phenomenal human experiences, and processes of practical and conceptual "meaning making" in human-robot interaction. (ii) Without such a descriptive theory, we cannot even begin to evaluate social robotics applications with respect to their impact on individual and social well-being. (iii) Without research-based evaluations, responsible regulation of the robotics market and responsible policy-making cannot get off the ground. Given that extant regulations prohibit long-term studies necessary for a fully relevant descriptive theory of human-robot interaction, the triple gridlock is complete.

The triple gridlock, which is a dimensionally expanded form of the “Collingridge dilemma” or double gridlock of evaluation and regulation (Collingridge 1980), cannot be addressed with currently available theories of technology and design strategies. Elsewhere we try to show this in greater detail (Seibt et al., under review), but here we want to offer at least two pointers. First, sociological theories of technology and descriptive frameworks developed by Science and Technology Studies — such as the Actor Network Theory (ANT) or the Social Construction of Technology (SCOT; Bijker et al., 1987/2012) approach — are empirical theories of behavior; they are conceptually not equipped to investigate cognitive processes at the microlevel of neuropsychology or phenomenology. Moreover, these theories operate with highly generic theoretical categories (“actor”, “technological artifact”) while ISR operates with a process ontology that can relate, in terms of general and quite specific categories, the theoretical idioms of behavioral, phenomenal, and neuroscientific research, as well as descriptions of cognitive architectures in robotics. The descriptive framework OASIS (Ontology of Asymmetric Social Interactions, Seibt, 2017, 2018b, 2019) distinguishes five modes of simulations in terms of similarity relations among processes and uses these to describe, at variable levels of precision, (i) how a robot simulates each component of a certain social action, (ii) in which way the human interacting with the robot views the interactive situation he or she is engaged in, and (iii) how an external observer (society) understands the complete asymmetric social interaction taking place between human and robot (each social interaction consists of a bundle of altogether seven interaction descriptions). In this way, a highly differentiated but ‘neutral’ idiom is available that can be terminologically latched onto from many different disciplinary perspectives and capture fine-grained differences of human social experience.

Second, in our current situation of ignorance about the long-term socio-cultural effects of human-robot interaction, only an approach that is strictly *driven* by ethical values can be ethically justified. Older design strategies of “user-centered” and “participatory” design are neutral with respect to the difference between instrumental utilities, subjective interests and ethical values in the proper sense; more recent guidelines for “value-sensitive design” (Friedman, Kahn Jr, & Borning, 1997; Friedman & Bainbridge, 2004) or “design for values” (Van den Hoven, 2005; Dechesne et al., 2013, bring values into view, but without clear distinctions between instrumental and ethical values. Only “care centered value-sensitive design” (“CCVSD”; Van Wynsberghe, 2013) has a clear focus on ethical values, relates to an established ethical theory (care ethics) and connects design recommendations concretely and procedurally to philosophical expertise in care ethics, while Dignum et al.’s (2018) “Design for Values for Social Robotics Architectures” focuses specifically on responsibility attributions and restrictions on software principles. ISR endorses the underlying insights of the latter two approaches but operates with a more general approach to (professional, philosophical) ethics and treatment of ethical issues, a more determinate (interactional) interpretation of values, and a specific maxime—see principle 5 below—that fulfills the demands of the cautionary principle mandated by our current situation of ignorance.

In short, then, ISR is particularly well suited to address the theoretical tasks and practical tasks necessary to resolve the triple gridlock. Concerning the descriptive tasks, ISR operates with an ontological framework that is conceptually sufficiently rich and precise to allow for interdisciplinary integration; concerning the prescriptive tasks, ISR uses a strictly value-driven approach and an effective selection principle that ensure the minimization of ethical risks in our current situation of ignorance about HRI.

The core ideas of ISR have been summarized in the form of five principles (Seibt et al., 2018), which state theoretical commitments, procedural requirements and a substantive ethical criterion.

The first principle concerns the *target* of the design process; crucially, the target should not be the robot, but rather the socially situated human-robot interactions enabled by the robot to be developed:

> *(P1)The Process Principle: The product of a research, design and development process in social robotics are not artifacts (robots) but socio-cultural interactions afforded by certain artifacts.*

As often observed (e.g., Turkle, 2011; Darling, 2015; Kahn, 2015), social robots are no longer *things* or tools that people use, but social agents that engage humans in social interactions and elicit empathy as well as moral concern. Principle 1 acknowledges this by switching from an object ontology to an interaction ontology, thereby forcing developers to articulate their constructional aims within a conceptual framework that brings them face to face with the fact that they are, in effect, engineering socio-cultural interactions. This means that Principle (P1) does not render the robot as 'less important' but emphasizes—using J.J. Gibson's technical notion of "affordances"—that choices in the robot's (physical, kinematic, functional) design carry socio-cultural significances and must be viewed in the light of these. Given the complexity of technology-mediated socio-cultural interactions, many different kinds of expertise are necessary to create such interactions in a competent fashion:

> *(P2) The Quality Principle: The research, design and development process must involve, from the very beginning and throughout the entire process, expertise of all*

disciplines that are relevant for the description and assessment of the socio-cultural interaction(s) involved in the envisaged application.

Moreover, it is crucial to keep in mind that interactions between two interactants are always also embedded in a larger socio-cultural and societal context. Consequently, it is not enough to design interactions that may be satisfactory for the people directly involved—a short-coming of traditional user-driven or participatory design models (cf. also Forlizzi, 2018). For instance, even if an interaction between a person and a sex robot may be satisfactory from the user's perspective, society at large needs to enter as a stakeholder and determine whether sex robots comply with relevant ethical norms (cf. Scheutz & Arnold, 2016). The deliberative mediation between the respective human-robot interaction situations and the societal norms and contexts draws attention to the complexity of socio-cultural interactions:

(P3) The Ontological Complexity Principle: Any social (socio-cultural) interaction must be described from (at least) three perspectives—first person, second person, and third person perspective. The research, design and development process in social robotics must integrate all three perspectives.

In other words, a social interaction of a greeting, for example, does not exist simpliciter like a chair or rock. It exists as the complex of three perspectival 'versions' of the interaction. (i) There is the interaction from my perspective—I take myself as performing a greeting, I take myself as someone who you see as performing a greeting, and I take myself as engaging with you in an interaction that from an imagined 3rd person perspective, i.e., in the way in which I understand the social norms, counts as a greeting. (ii) There is the interaction as you perceive it—which has the same parts as in (i), mutatis mutandis. (iii) There is the factual third person perspective, the societal norms that define what the first and the second agent have to do in a 2-person greeting. Supported by the insights of the pragmatist tradition in metaphysics, in ISR, the ‘truth’ of a socio-cultural interaction is always a matter of procedural, dialogical mediation between these three perspectives. That social reality is not only complex but also intrinsically dynamic is reflected in the fourth principle of ISR, which prescribes tight internal and external feedback cycles, to ensure context sensitivity:

> *(P4) The Context Principle: The identity of social (socio-cultural) interactions is relative to their (spatial, temporal, institutional etc.) context. The research, design and development process in social robotics must be conducted with continuous and comprehensive short-term regulatory feedback loops (participatory design) so that the new socio-cultural interaction is integrated with all relevant contextual factors.*

Finally, an integrated social robotics perspective begins with the question of values – which socio-cultural interactions should we want to preserve or increase, and how can robots be used for this purpose? Putting values and well-being before utilities is not quite enough to minimize—in our current situation of ignorance—the risk of creating changes in socio-cultural practices that are undesirable or harmful. An additional selection filter is needed in order to ensure that social robotics applications do not disrupt beneficial practices:

> *(P5) Values First Principle: Target applications of social robotics must comply with a (deliberatively established specification of the) non-replacement maxim: social robots may only do what humans should but cannot do. (More precisely: robots may only afford socio-cultural interactions that humans should do, relative to value V, but cannot do, relative to constraint C). Throughout all stages the research, design and development process in social robotics should be value-driven, i.e., governed by axiological analysis and evaluation.*

An example for a robot that observes the non-replacement maxim could be a rescue robot, which serves people in unstable or unsafe environments. To be sure, both loosely formulated as slogan and in its more precisely formulation, the non-replacement maxim is far from clear-cut – its purpose is to generate ethical debate and deliberation from the outset, continuously intertwining our technological creativities with our ethical competence. Principle 5 has the effect that applications developed with the ISR approach can be most straightforwardly justified relative to more comprehensive requirements of prudence or practical rationality, in contrast with value-sensitive design models—to pursue ethical values in our current situation of ignorance is more easily justified than the pursuit of, say, epistemic values, such as transparency.

These five principles—further motivated and developed in Seibt et al. (2018a) and in Seibt et al. (under review)—characterize the particular current *praxis* of an international research team with 15-26 members dedicated to exploring the ISR approach full-scale, learning-by-doing. However, could they also be more than reconstructions of a praxis? Could they be of use as more general rules or reflection points that can be combined with other types of research, design and development processes? In the following, we present a case study of inserting a 'light' version of ISR into a project development by discussing the effects of these principles on the use case design process in the SMOOTH project, and possibly beyond.

3. Use Case Development in SMOOTH

The SMOOTH project,[1] funded by the Danish Innovation Foundation, aims to develop a responsive robot for elderly care in a Danish elderly care facility. The ideas for the use cases had been developed in interaction with SPIR project Patient@home (www.patientathome.dk/), with the funding institution, the Danish Innovation Foundation, and with representatives from the elderly care facility the robot is developed for, as well as based on experience by our project partner Fraunhofer IPA. The three use cases that constituted the starting point for this project are described in Figure 1. The first use case is intended to support caregivers in strenuous and repetitive tasks, such as laundry and garbage collection. Here, it is the personnel who will primarily interact with the robot directly. The second use case addresses dehydration, which constitutes a problem in elderly care in general since with increasing age, people may lose their sense for thirst. The robot is envisioned to serve water to the residents and encourages them to drink more. The third use case consists in guiding elderly people and help them navigate within a care institution.

As soon as the project had started, we took further steps towards the development of the use cases. In order to understand stakeholders' real needs and the workflow to which the robot would have to contribute, qualitative methods (interviews, ethnographic observation, focus groups, prototyping) were used and all relevant stakeholders were involved, taking a user-centered design approach (Preece et al., 2015; Holtzblatt et al., 2018); thus, after initial idea generation and iterative development in interactions between the SMOOTH consortium and Patient@home, Innovationsfonden and Køge Kommune during the preparatory stages of the project, the following steps were taken:[2]

[1] http://smooth-robot.dk/en/home/

[2] The user-centered use case development is described in more detail in Juel et al. (2018).

Figure 1: Initial use case proposals (images created by the Danish Technological Institute)

a) 24-hour ethnographic observation at Ølby elderly care center (Køge Kommune), the Danish partner institution for which the robots are being designed; the observer observed and documented the work flow in two departments of the care institution with a particular focus on how garbage and laundry was handled, how the mealtimes were organized, who drinks what at what times of the days and who is guided where;

c) focus groups, user interviews and prototyping workshop at Ølby elderly care center; here, the use cases in general and those issues that came up during the observation in particular were discussed in depth in direct interactions with residents and personnel;

d) presentation of results to the SMOOTH consortium and discussion of the use cases with representatives from Køge and Ølby elderly care center and a representative from the SMOOTH ethical advisory board;

e) workshop with Køge Kommune, with participation of an industrial designer and anthropologist, discussing the robot specification requirements in relation to the use cases;

f) stakeholder workshop at Køge (involving key decision makers of the local administration);

g) joint development of robot specifications during consortium workshops;

h) site visit with observation and interviews at different institutions at Køge Kommune;

i) workshop 'Integrative Social Robotics Hands-on' at the Robophilosophy 2018 conference in Vienna (Austria), where the use cases were presented to a general audience, and where invited experts discussed the use cases from ethical, geronto-psychological, design and HRI perspectives;

j) consortium meeting, in which all the results achieved were considered and discussed together;

k) prototyping workshop at the elderly care facility in Køge using mock-up robots.

During this iterative development phase, the initial use case ideas were revised and refined while taking aspects of computational and economic feasibility into account, which led us to making several adjustments to the use cases:

First, we found that the residents at Ølby elderly care center overall receive a highly individualized care. Due to the small units and the high number of personnel per resident (two on the early shift, two on the late shift, one on the night shift, for 5-6 residents), a high level of personalized care is provided. The caregivers know the residents very well and therefore anticipate, for example, what they would like to drink, when they want to drink what and from which container. The kinds of drinks residents consume and the relevant containers are highly diverse; crucially, none of the current residents drink water, and few would be able to drink it from a plain glass. We therefore adapted the use case from care for hydration, which had been found to be crucial in German elderly care facilities (see Graf et al., 2009), to serving coffee between the meals in order to encourage residents to socialize in the common area instead of disappearing into their rooms. The focus has thus changed from providing a solution against potential dehydration to the social aspects of residents' life, rather aiming for the kinds of social effects of snack delivery by a robot described by Lee et al. (2012).

Second, regarding the laundry and garbage collection task, our observations, interviews and exchanges with the care personnel revealed that caregivers walk back and forth between the residents' rooms and the garbage and laundry rooms many times per hour, often with heavy loads. To employ a robot here to support the caregivers seems very useful. However, also here several restrictions emerged. For privacy reasons, given that the robot can collect personal data, the robot may not be allowed to enter residents' rooms. Another issue is hygiene: if the robot drives from room to room, it may spread germs, especially in the case of multi-resistant infections. If the robot is not allowed to drive into residents' rooms, though, this may negatively influence the amount of support the robot can provide since caregivers still need to carry laundry and garbage through residents' rooms themselves and into the corridor where the robot is waiting.

Regarding guiding, it turned out that while longer, activating walks guided by the robot might be useful (a resident actually asked for such an application), caregivers spend a lot of time accompanying residents from their rooms to the dining table in the common space. Several of the residents cannot find their ways themselves, even though most are physically able to walk by themselves or with a stick or walker. Since the robot was not anticipated to be usable outdoors, we decided to restrict the use case to indoor guidance. The three use case scenarios we thus arrived at after the iterative design process described in a) – k) are the following:

Laundry & Garbage Collection **Scenario**

Every day, the caregiver walks into the resident's apartment to collect the garbage from the bathroom and from under the sink of the resident's kitchen. Here we see possibilities: Either the robot follows the caregiver and waits now outside the resident's room for the garbage the caregiver puts into the robot, or the caregiver simply takes out the garbage in the respective bin and leaves it in the corridor for the robot to pick up. Then caregiver and robot either walk together to the next resident's room to do the same, or the caregiver collects the garbage herself and just leaves it outside again for the robot to pick up. The robot takes the garbage to the storage room autonomously. Then the robot returns to the resident's room, while the caregiver chats with the resident and makes her bed, and waits for the next task. The caregiver checks whether there are dirty clothes that need washing. She places the laundry in a basket outside, where the robot picks it up and takes it to the laundry room. When the caregiver is done, she follows the robot and fills the laundry into the washing machine.

Whether the robot joins the caregiver in the resident's room or not to collect the laundry or garbage there directly, whether it waits outside or whether it picks up the laundry and garbage autonomously will depend on, for instance, hygienic considerations and on whether the resident agrees that the robot may enter his or her room. Following the caregiver into residents' rooms and being of logistic assistance all the time has the advantage that the caregiver does not need to carry the laundry very far; the disadvantages of this approach are that the robot drives very slowly for safety reasons, so that it might also slow down the caregiver, and that the robot would collect audio and video data in residents' rooms, which may evoke ethical problems. These would be avoided if the robot picks up laundry and garbage autonomously.

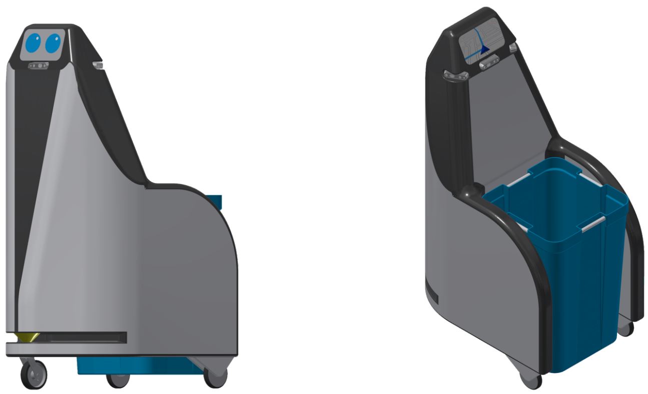

Figure 2: The SMOOTH robot design after the user-centered design process

Guiding Scenario

At each mealtime, the caregiver knocks on the resident's door, goes in and tells the resident to come to the dining table. She knows that the resident needs help in finding her way, so she calls the robot. The caregiver introduces the robot, and the robot establishes contact. Then the caregiver walks off to inform the next resident to come to lunch. Then she sets up the table, welcomes the residents and helps them get comfortable.

The robot waits for the resident to get up and get ready and chats with her about the weather or about the menu. Then the robot accompanies her out of her room and to the dining area.

Here again, we foresee two different versions: If the robot may not be allowed in the residents' rooms, the 'hand-over' between caregiver and robot would have to occur outside the room. Ethical and hygienic issues are avoided if the robot waits outside the resident's room, but then less time will be saved because the resident needs to be ready to walk when the robot takes over, whereas it could accompany and encourage the elderly person already while she is getting ready if it was allowed inside the room. In SMOOTH, both versions will be implemented for the caregiver or the respective institution to choose between.

Serving Drinks Scenario

In the morning after breakfast, the robot drives around and asks the residents whether they want to stay in the common area and whether they want something to drink. One resident has not finished her drink, and the robot takes her cup to the common room and encourages her to drink and entertains her while she is sipping on her cup. Several residents gather in the common space because they want to watch each other interact with the robot. They take their turns in ordering their drinks. They ask the robot to play some songs from when they were young. They remain in the common area until lunch. After lunch, the robot invites them to take a walk. After the walk, it again offers them a drink, which makes the residents stay in the common room.

Besides adjusting the activity scenarios for the robot, the robot design (see Fig. 2) has been developed further to better meet the requirements of the tasks (see Juel et al., 2018). For example, in order to carry laundry and garbage, the robot was designed to be able to autonomously pick up laundry and garbage baskets and to transport them securely and autonomously. Furthermore, the robot was equipped with sensors for audio localization, speech and vision (cameras and a laser range finder), with a Raspberry pie screen to display the eyes, and with a touchpad for localization interaction.

These use cases and robot development steps described above, which were carried out based on a set of well-established methods in a user-centered design approach (e.g. Holtzblatt et al., 2018), constitute the starting point for our exercise in applying ISR to the SMOOTH use case development.

4. The Integrative Social Robotics Approach Applied

In the following, we investigate what can be gained from applying an integrative social robotics approach (ISR) to use case development in Smooth. The discussion was first initiated during a workshop organized at the Robophilosophy Conference 2018 in Vienna (Austria) in order to explore what the ISR approach could offer at this stage. In observance of the ISR principle P2 (involve all relevant expertise), we invited experts with disciplinary backgrounds that currently are not present in the interdisciplinary developer team of SMOOTH, namely psychiatry, philosophy (ethics), sociology and design, but prima facie matter for the use cases. The experts were asked to comment on the use cases of the SMOOTH project from their disciplinary perspectives, and a panel discussion with SMOOTH developers followed. To consolidate and extend this discussion, the experts agreed to respond after the event in writing. In this section, we report the content of these exchanges and responses, with two aims:

On the one hand, by applying the five principles of integrative social robotics to the SMOOTH use cases, the socio-cultural significances of the interactions engendered by the concrete use cases of SMOOTH come into view; this can provide guidance for similar robotics projects in similar contexts and illustrates the potential contributions of an ISR approach beyond user-centered design. On the other hand, at a more general methodological level, by discussing the five principles on concrete examples, we can see to what extent they can inform robot development and whether they serve their purpose of allowing for a deeply integrated robot development process that yields culturally sustainable applications.

In the written exchanges after the workshop, we posed the following five questions to the workshop's experts which take off from the five principles of ISR proposed by Seibt et al. (2018):

· ad P1: From your (disciplinary) perspective, what is your take at the 'interactions, not robots' principle, and what kinds of socio-cultural interactions are being designed in the three use cases?

· ad P2: From your (disciplinary) perspective, what kind of knowledge needs to be taken into account? How can your discipline contribute to the use case development?

· ad P3: From your (disciplinary) perspective, who are the relevant stakeholders, and what are the consequences of considering the three use cases from a first, second and third-person perspective?

· ad P4: From your (disciplinary) perspective, what are the socio-cultural contexts relevant in the three uses cases?

· ad P5: From your (disciplinary) perspective, what is the relationship between the tasks the robot is supposed to take over and how things are currently done? Do the use cases adhere to the non-replacement maxim (such that the robot does not replace human roles)?

The following subsections compile the answers, which are largely preserved verbatim to reflect the way in which the experts—and co-authors of this paper—tried to avoid technical idioms to create a shared communicative space. While transdisciplinary communication would require a shared technical vocabulary, such communication with terminology deflation is surely an important precondition for creating transdisciplinarity. It is important to note, though, that the shared communication space created in the frame of mind of *commenting* does not generate the joint space of imagination and visualization mentioned at the end of section 3, which is created in joint problem solving. That is, in the full-scale version of ISR social robotics applications are jointly developed in interdisciplinary developer teams, sharing their conceptual spaces from day one. By contrast, the following reactions document the potential usefulness of the five ISR principle as reflection points for a temporary encounter with the ISR approach. In this way, we can identify the exact contributions of the five principles and of the recommendations made by ISR that go beyond the more mainstream user-centered design approach. We return to this point in the discussion.

4.1 The Process Principle P1: Interactions, not robots as the target of the design process?

The process principle (P1), ‘interactions, not robots,’ draws attention to the fact that designing social robots primarily means to design (affordances for) interactions, which therefore should be taken to be the starting point of the design. As such, the principle was embraced by all authors as necessary and useful. The ‘interactions, not robots’ principle seems however mostly directed towards those kinds of robot development projects in which the technological development is in the foreground and in which the applications only serve to showcase robotic technologies and progress. In contrast, the SMOOTH use cases were developed from a user-centric perspective taking different stakeholder perspectives into account and represent very common tasks one finds in many care facilities, not only in Denmark and not only in elderly care. As sociologist Astrid Weiss points out, in this respect the SMOOTH project is similar to some other projects, such as the EU-project HOBBIT (Bajones et al., 2018) in which a robot was developed to facilitate independent living at home and to prevent that the elderly person needs to move to a care facility; similarly, in the STRANDS project (Hawes et al., 2017), the patrolling robot developed was oriented at the care personnel's needs to ensure that everything was okay and to guide lost residents back to their rooms. From this perspective, the implicit criticism, to orient too much at technical feasibility instead of at the kinds of interactions needed, does not apply to the SMOOTH project, nor to some other recent robot development projects.

Nevertheless, the principle draws attention to the question what kinds of robots we need in order to facilitate those interactions that we wish for. This then leads to the question what interactions we aim for and how we arrive at the definition of such interactions. This concern is introduced by philosopher Raffaele Rodogno in section 4.1.1. A second issue that comes up when taking the process principle P1 seriously is that it may suggest that the physical nature of robots has no implications for potential interactions and may hence be neglected. Still, robots are physical things – things that have to be given a form. This physical form enables particular types of interactions and restricts others; it can therefore not be separated from the interactions it supports, which is discussed by designer Majken Kirkegaard Rasmussen in section 4.1.2. and discussed further between the authors. In addition, her discussion of the tight coupling between robot form and the resulting interaction also shows how even though the use cases in SMOOTH were developed with interaction in mind, other considerations, in this case concerning the cost of the robot, can influence robot design. From this perspective, P1 receives some additional relevance as a principle that can help set priorities or at least clarify what is at issue.

4.1.1. The interactions targeted in SMOOTH

The interactions that constitute the target of the use case development need to be understood in the context of a *practice*, here the existing practice (or practices) that we find in a nursing home. The elderly move (or are moved) into these homes to have their needs/well-being better attended to by professional caregivers. At the most general level, then, the interactions with which we are concerned are those involved in the practice of professional caring. This practice has the well-being of the nursing home residents at its regulative center. Or again, the residents' well-being is the good whose realization gives a structure to this practice and the interactions it involves.

Note that professional care is different in some respects from other practices that have caring and well-being at their core such as friendship, parenting, and spousal relations. Professional care focuses on the residents individually: It involves mostly a one-to-one relation between the care-giver and the care-receiver. The practice, then, does not consider the well-being of the residents as an aggregate to be maximized. Nor is it concerned with how best to distribute well-being-enhancing resources among individuals. That kind of calculation is central to a different practice, which typically involves individuals in their role as managers and administrators (if not politicians) rather than care-givers. Finally, in the context at issue here, caring involves a relationship/bond (between care-giver and care-receiver) that is formed, maintained, and renewed around a number of specific activities (assisting the care-receiver out of her bed, with her bath, with her meal/liquid intake, with her prescribed medication, with her daily exercises, etc.), which all go to form the relevant caring practice. They are connected by the relation between the care-giver and the care-receiver, a relation which the performance of each of these tasks may help consolidate or weaken. As Joan Tronto (1993) and Aimee van Wynsberghe (2013) note, the idea is precisely that care is to be conceived of as a holistic practice, and not as a series of single, independent tasks:

> "To exemplify this shift from task to practice, let me use the [task] of lifting. When a patient is lifted by the care-giver, it is a moment in which the patient is at one of their most vulnerable. The patient trusts the care-giver and through this action a bond is formed and/or strengthened which reinforces the relationship between care-giver and the care-receiver. The significance of this is apparent in the actual practice of lifting but comes into play later on in the care process as well. … trust, bonds, and the relationship, are integral components for ensuring that the care receiver will comply with their treatment plan, will take their medication and be honest about their symptoms." (Wynsberghe, 2013, pp. 417)

The health of the relationship between care-giver and care-receiver affects the chances that caring realizes its end or good, i.e., the care-receiver's well-being. In sum, caring in the context at issue here is a practice aimed at realizing the care-receiver's well-being; it involves a relationship/bond between the care-giver and the care-receiver that is built and maintained around certain context-specific tasks, the good execution of which is (likely) interconnected and ultimately contributes to aspects of the resident's well-being. When designing a robot for elder care, the robot has to be so designed as to afford interactions that support these aspects of resident well-being.

To sum up, the process principle P1 draws attention to the kinds of interactions targeted, and it thereby introduces considerations of relational and valuational dependencies of interactions within the use case scenarios, which may easily go unnoticed if the focus remains on the robot or on individual tasks the robot may take over.

4.1.2. Physical form shapes interactions

Many studies illustrate how the physical form of the robot impacts how it is perceived, changing, for example, how trustworthy, friendly or intelligent the robot appears (e.g. Kalegina et al., 2018); that is, even changing minor details such as the hairstyle of the robot, alters the traits ascribed to it (Hegel et al., 2010). When giving a form to a robot, an important decision concerns the question whether the robot should have anthropomorphic features or not; for instance, a robot with a face may involve people more, can use known signals to indicate what it is up to, like where it is going, and anthropomorphic design provides it with something like a personality or identity. In contrast, a purely functional design may lead to lower expectations – which can be useful if this corresponds to the robot's real capabilities. Relatively small transformations of the robot's face may drastically alter its appearance (see figure 3 for examples, cf. also Kalegina et al., 2018).

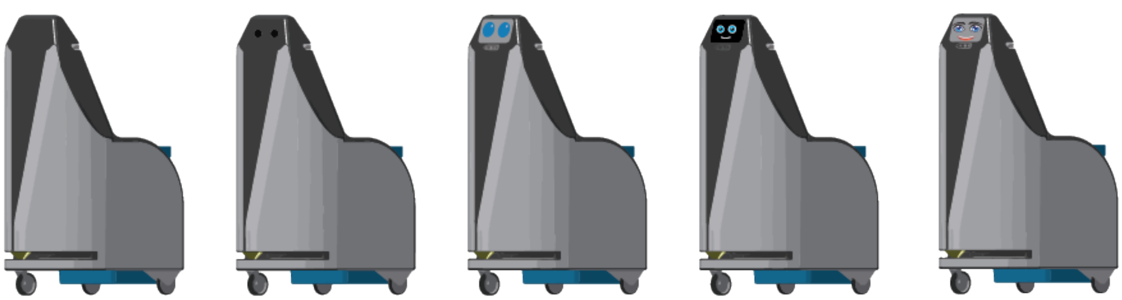

Figure 3: The current SMOOTH robot with different faces

The robot designed for the SMOOTH use cases could have a variety of different shapes while still fulfilling the required functions and performing the desired interactions types. Taking the drinks serving scenario as an example, from a functional interaction perspective, it would not matter if the robot was shaped like a drinks trolley, a globe-shaped bar, a cabinet, a cute cartoon-like character, a stylized butler or like the current version of the SMOOTH robot. All of these possible robotic shapes could perform the same functional interactions or *social interaction types* specified in the activity scenario, such as politely offering drinks to the residents or encouraging them to finish their drink. However, the physical form would shape the interactions and expectations in different ways, blend in or stand out in the context, and conform to residents' expectations of a robot to a greater or lesser extent.[3]

When comparing two different designs from the design process (see figure 4), it becomes clear how they frame the drinks serving interaction very differently. In the first sketch, the robot serves the drinks on a tray-like surface placed in the front of the robot, whereas the design created later in the process has the serving attachment in the back. The sketch in figure 4 illustrates how the two different shapes create very different situations. The first robot faces the people it is serving, whether they are to the side or in front of the robot. In the later iteration, the serving attachment is located in the back of the robot, which entails that the robot turns its "back" to the people it is serving.

Viewing the design from this perspective, technical concerns have outweighed social concerns in the design. Indeed, cost considerations play a considerable role. In particular, multifunctional robots, such as the SMOOTH robot, pose the challenge that a single design is meant to address very different situations and tasks, forcing the roboticist to balance acceptability, cost and functionality. Taking the SMOOTH robot as an example, the robot performs very different tasks like serving drinks and transporting laundry and garbage; since this could cause irritations regarding the robot's social roles, drinks on the one hand

[3] Similarly, the appearance of the robot can invite interactions with elderly users to larger or lesser extents; the SMOOTH robot is not very tall and thus of appropriate height for encounters with a wheelchair user or a person bending over a walker, and it is designed to adapt its speed to the speed of the person it is accompanying; however, whether the robot embodiment is suited to serve all of the needs of elderly people and their embodiments would have to be determined empirically.

and laundry and garbage on the other should probably not be transported with the same modules. Therefore, a design in which the robot has an attachable module for serving drinks use case was considered. Furthermore, for robot navigation purposes, at least one laser scanner is required in the front, which would be partially blocked if the drink serving module was attached in the front. This would require an additional laser scanner at a cost of around 37.500DKK/5.000€, making the whole robot more expensive. Generally, from a monetary perspective, it is necessary to find design alternatives without reducing the basic functionality. Such a trade-off between interaction quality on the one hand and cost efficiency on the other is discussed in relationship with principle P5 again in section 4.5 below.

Figure 4: Left: early iteration and right: final design of the drink serving robot

As another example of the impact of form on the kinds of interactions arising between robot and use, in the laundry transportation scenario (see figure 1), placing the load that the robot needs to carry in the back rather than in the front entails that there is no direct contact with the robot. If the robot were turned the other way around, it would allow for “eye contact” between the staff and robot when carrying out the task.

The two examples illustrate how different forms create different interactions, highlighting that the robot as a “thing” is central to designing the desired interactions, but also that the focus on the desired interactions reveals constraints and goals for the design of the robot that otherwise may have been missed.

To sum up, the first principle of integrative social robotics, to target interactions, not robots in the design process—or more precisely: to target interactions, which imply robotic designs--leads to a conscious choice of robotic designs (physical and kinematic shapes, functionalities) in order to achieve particular goals, which in the case of SMOOTH range from supporting caregivers to providing care.

4.2 Quality Principle P2: Wide interdisciplinary scope?

In general, there are no specific requirements for what disciplines are necessary to include in the design process; however, it is important to include disciplines that can further our understanding and design of social and socio-cultural interactions, as well as context specific knowledge. The challenge of the interdisciplinary process is to balance and integrate the different contributions from the different disciplines involved in the design and development process.

What disciplines are brought into the design process furthermore depends on which disciplines contribute to designing interactions working for the desired purpose, in this case, the realization of specific aspects of the residents' well-being.

In principle, all contributing disciplines could be covered under the heading of human-robot interaction (HRI), which is a research field that is highly interdisciplinary in itself and comprises expertise in robotics, psychology, sociology and design, to name but a few. However, interdisciplinarity applies to the field of HRI as a whole, and no single individual can be expected to bring in expertise from all perspectives. Thus, for practical reasons, in the current paper it is useful to think in terms of the contributing disciplines in order to identify what kinds of expertise are necessary.

What has become obvious in the discussion of the use cases so far is that a user-centered design approach is mandatory, and thus that experts in user-centered design should be involved to identify the needs of users and direct stakeholders. Sociologists, for instance, add a broader societal perspective and help understand the social context and workflows the robot will be part of (e.g. Weiss et al., 2011; Mutlu & Forlizzi, 2008).

Design, or the designer, provides a different set of skills to the process, both specifically to the process of shaping the physical form of the robot, but also by being able to visualize

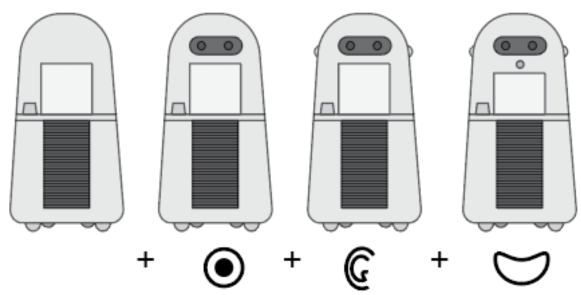

Figure 5: Feedforward design of visual, audio and verbal capabilities for the SMOOTH robot

ideas early in the process, making it easier to evaluate them. Design is a future-oriented practice, concerned with what ought to be rather than with what is (Simon 1996), utilizing "what if?" questions to imagine and illustrate future scenarios. Beyond this, designers bring form-giving skills to the process, skills extending beyond giving the robot an appealing exterior. Concepts such as feedforward (Wensveen et al., 2004) support designing robots where the physical form informs about interaction possibilities before interaction happens. Functional feedforward informs the user about the more general purpose of a product and its functional features by creating visible indicators of the functionality it has and how it can be interacted with. Figure 5 illustrates this on the initial design concept of the SMOOTH robot. The physical features of the robot could inform a user about its capabilities; if the robot has eyes, it signals that it sees something, if it has little bumps at the sides of its head, similar to ears, it suggests that it can hear something and can be talked to. However, often in robot development, contributions from design are not taken into account; for instance, what looks like eyes on a robot is often not where it sees, and the microphone may not be placed where ears would be expected to be.

To sum up, a designer can contribute to robot development by implementing functional feedforward that can help users identify at a glance what the robot's capabilities are and how it can be interacted with (see also Fischer, 2011).

While the designer contributes to the functional feed*forward*, interaction expertise (for instance, based on experience with ethnomethodological conversation analysis, cf. Sacks et al. 1974) is needed to take care of the feed*back*, i.e. of what happens after one interaction partner has produced some kind of behavior. The interaction expert can predict users' behavior and provide them with all the feedback and information they need for the interaction to be successful, smooth and enjoyable. This may include verbal behavior, such as what to say, which words to use or how to say them; paralinguistic behavior such as speech melody (Fischer et al., under revision) and non-verbal cues, such as eye gaze (Andrist et al., 2014; Admoni et al., 2014; Fischer et al., 2015); as well as interactional features, such as timing (Lohan et al., 2012; Fischer et al., 2011; Jensen et al., 2017ab) and mutual adaptation (Strupka et al., 2016). Moreover, the interaction expert provides measures for interaction quality and thus contributes crucially to the evaluation of the interactions designed.

Knowledge about the specific context is especially relevant when the case involves special populations, like the elderly who suffer from dementia in the SMOOTH project. Here expert knowledge for instance from psychiatry is required to provide the necessary knowledge on how to best design robot appearance, behavior and applications to provide the best possible care.

In the development process, roboticists naturally play a central role, given their technical expertise as well as their ability to manage cost considerations in the development process.

Finally, philosophical expertise can support the development of the SMOOTH use cases in three ways. First, using phenomenological analysis relative to existential and ethical categories, the philosophers in the discussion remarked immediately on the problem that the multifunctionality of the robot as garbage disposer and server of drinks may be perceived, given current socio-cultural significances, as an infringement of the dignity of the residents of the care-center. Second, applying conceptual and value-theoretic analysis, the philosophers clarified the notions of care-practice and the particular goods connected with it; they helped to focus the attention onto the interactions that realize the particular good of the practice (the individual resident's well-being when caring is the practice at issue) while remembering that these interactions come together as part of *one* practice (remember the idea of caring as a holistic process in which performance of a specific task can affect performance of other tasks). Third, by evaluating the targeted interactions from the point of view of professional ethics during the design process, the philosophers support the development of the application by protecting it beforehand against later criticism by ethical councils.

This list is not likely to be exhaustive; not only will specific applications, like in the case of SMOOTH, the employment of the robot in an elderly care facility, require specific knowledge and competences, like the expertise of a psychiatrist specialized on age-related cognitive decline, but also other techniques and methods can potentially enrich the spectrum of perspectives taken on social robots in even non-obvious fields, such as narratology (cf., for instance, Cheon & Su, 2018). To conclude, it is clear that in such an important matter as how we want robots to be integrated into society, we need to draw on as broad knowledge as possible.

4.3 Complexity Principle P3: First, second and third person perspective?

The complexity principle was found to be extremely useful and to yield many interesting discussion points. The complexity principle is to some extent related to Forlizzi's (2018) request to broaden the range of stakeholders considered in the design process and to address their various different relationships with a technology beyond being 'a user'. But it goes far beyond it since it requires that developers ask: who is the application for? How will the intended 'users' perceive the robot? How will they perceive themselves in their interactions with the robot, relative to bystanders? How will society at large interpret this interaction relative to socio-cultural and ethical norms? Philosopher Raffaele Rodogno leads the discussion in sections 4.3.1 and 4.3.2 below. As the discussion shows, identifying the 'users' does not necessarily mean that their experience with respect to the robot is taken into account. The complexity principle calls on developers to clarify who *all* the stakeholders are, including stakeholders in larger societal contexts, how they perceive the target interactions, and whether these perceptions match with the intentions of the developer teams and the user's self-perception. Ethical deliberations about the admissibility of robot applications typically pertain to mismatches in the perspectival understanding of the targeted interaction (one may ask, for instance, if it is admissible to involve a resident in an interaction that is undignified from the third-person societal point of view, if she herself experiences the interaction as positive (Seibt, 2018). We discuss the potential effects of (potentially entirely satisfactory) interactions between direct users and a robot on other members of the same group, using the example of fairness in the context of an elderly care facility (see section 4.3.2). Moreover, we address issues of interaction quality, i.e. the intersection between first- and second-person perspective, in section 4.3.3. Finally, we discuss the implications of the complexity principle on the way scientific knowledge is brought to use. The complexity principle P3 thus provides a fruitful anchor point for the bridging between robot development and broader societal discussion.

4.3.1. First person perspective: a robot for whom?

In the discussion of the consequences of taking different perspectives in use case design, one first needs to consider exactly who the stakeholders are and how these will perceive the target interaction from a first-person perspective, as well as how they will take themselves to be perceived from the robot's perspective, as well as from the perspective of a third party—their immediate peers, or actors in the larger societal context. In the case of the SMOOTH project, the stakeholders who have been taken into account thus far are the residents and caregivers, the administration of the elderly care facility, and relevant representatives at the municipality. Moreover, an important stakeholder is of course the funding institution that sees value in funding the development of a robot for elderly care. Taking the perspective of the complexity principle, we may ask now who is supposed to experience the SMOOTH robot from a first-person perspective, and for whom the robot has primarily been designed. Considering the three proposed use cases, the robot appears to have been primarily designed from the staff's perspective, as it takes the point of departure in offloading activities to the robot that are presently performed by the staff. If the residents were the starting point for the design, a completely different set of activities may have been targeted. What exactly these are is particularly challenging to identify in the drink serving and guiding use cases since the residents may be afflicted by dementia and are thus hindered in expressing their needs, problems and capabilities, making it challenging to take them as the starting point for the design (as in participatory design approaches, for instance, Lee et al., 2017). Consequently, although the residents appear to be the primary users in two out of three scenarios, the robot is designed based on replacing the staff's current activities. From the staff's perspective, the robot may gain high acceptance because it reduces their workload and provides them with more time for care. In contrast, from the residents' perspectives, the robot may, for instance, be experienced as removing care and personal contact if the time gained for the staff might not be used specifically on them.

Furthermore, considering whom the robot is designed for draws attention to the possible impact of such a robot beyond its immediate users, such as, for example, that introducing a robot might also cause grandchildren to visit even more often because they consider the robots cool (Šabanović et al., 2013). Some of these effects may be completely unpredictable and not all negative; for instance, Forlizzi (2007) shows that introducing a robotic vacuum cleaning robot in families had several social effects that were beyond those designed for; for instance, the responsibility for house cleaning was distributed more within the family, and teenaged children started to participate in the house cleaning activities. Similarly, Lee et al. (2012) report that a snack robot created new opportunities for socializing. Thus, considering the different perspectives illustrates that the same robot could be responded to very differently by different users in the three use cases, and depending on whose perspective is taken, the design of robots may result in different solutions (cf. also Šabanović, 2010; Weiss et al., 2011).

4.3.2. Matters of fairness

The complexity principle furthermore draws attention to issues at the intersection between second-person and third-person perspective. For example, a problem regarding fairness emerges concerning the guidance use case: How will the resident feel about being accompanied to the dining room by a robot rather than a person? Will she be indifferent, if not happy about the change, or will she feel like a second-class resident on whom human care-givers cannot be spared? Will she think that it is unfair that others get to be with humans but not her? Will she feel left behind or betrayed by her care-giver? Will she feel as a being of lesser value or worth? Or inversely, will others feel envy at those residents who get to chat and walk with the robots? These questions raise issues of what the human-robot interaction situation communicates to the user (second-person perspective) in comparison to others (third-person perspective).

If the interactions give rise to feelings of injustice, trust may be lost, the relation between care-giver and care-receiver may be damaged, and other parts of the holistic caring practice may suffer as a result, as will, in the end, the resident's well-being. Moving forward, we need to study whether perceptions of injustice turn out to be a problem, and if so, consider introduction strategies; for instance, residents could be informed that they would all take turns with both human and robot-carers.

4.3.3. Second Person Perspective: The quality of experience

An important consideration especially for robots in the care sector is how the intended users will perceive of themselves as an interaction partner for the robot—when two people interact, each knows that he or she is perceived as a 'Thou' by the other. But will the user of this application feel that he or she is a 'Thou' for the robot? This question becomes relevant for the care-receivers among the intended users of the SMOOTH use cases, extrapolating from observations made within nursing science. Sally Gadow (1985) noted that during illness and treatment, doctors and other health-providers tend to refer to the patient and her body in mechanistic terms, as an object in need of repairing. Professional touch is required in physical examinations, and other forms of touching involving intimacy and personal meaning need to be avoided. Patients, however, usually continue to experience their body as lived rather than as objects, and, as a result, they feel objectified. Gadow shows how, by way of empathic touch, ill persons can be attended to objectively without being reduced to the status of an object. Empathic touch is required in caring relationships to affirm the “immediate, lived reality of the patient…. [E]mphatic touch affirms, rather than ignores, the subjective significance of the body for the patient” and is “an expression of the nurse's participation in the patient's experience” (1985, 40–41). Assuming that empathic touch plays an important role also in elderly care, the introduction of robots that cannot provide such touch may be problematic, potentially leading to a feeling of objectification among the residents and, ultimately, to a loss of well-being. In our observations carried out at the elderly care facility in Denmark, we have found caregivers to use every opportunity to administer such a kind of touch, for example, during meals, while accompanying the residents, during direct interactions or simply when passing. Currently, healthcare robots are not enabled to touch the residents, let alone provide empathic touch. Do the robots have compensatory strategies? If the robots turn out to be less effective than human care givers, nursing home managers will face decisions about the most efficient and fair distribution of well-being resources.

Similar issues can be raised regarding all aspects of interaction quality; however, emphatic touch has been empirically shown to be useful, whereas the effects of being talked to in a human, friendly voice or being responded to within 300msecs (Jefferson, 2004) are either less well studied or their role is considered less crucial (but see Jensen et al., 2017a). Nevertheless, studies on the pragmatic effects of interactional features (such as gaze, tone of voice, response time etc.) indicate that they all contribute to relationship regulation (e.g. Lohan et al., 2012; Andrist et al., 2013, 2015; Jensen, 2018), and thus that lack of comforting, trust-building signals that manage interpersonal relationships or the use of inappropriate behaviors may pose considerable problems for interactions with residents suffering from dementia or other restrictions (e.g. Ebesberger et al., 2016). Correspondingly, the caregivers and residents involved in the user-centered design approach in SMOOTH repeatedly asked for a soft and friendly voice and polite behaviors. While the SMOOTH project targets responsive, polite, dialogical interactions, there are simply technological restrictions to building robots that are able to produce the relationship building behaviors required in the context of elderly care.

4.3.4. Vulnerable users and scientific knowledge as a stakeholder

The complexity principle is difficult to apply when it is not transparent how users or stakeholder experience the robot. Many of the residents in the care facility for which the SMOOTH robot is being developed suffer from some kind of cognitive decline and thus cannot speak for themselves to the extent required for a user-centered or even participatory design approach. Here we have to rely on knowledge about the typical needs, problems and capabilities of the typical population afflicted by dementia, which introduces another kind of stakeholder into the discussion, namely the scientific community and its current knowledge about dementia. During the Robophilosophy conference, many recent findings on the cognitive abilities and their preferences were brought in by an expert psychiatrist from the University of Vienna, which led to concrete design recommendations. At the same time, the caregivers working directly with the elderly in person usually have a good feel for what their residents' current needs, preferences and aversions are. However, sometimes the recommendations from different resources may differ, as in the case of anthropomorphic design. Here the dementia expert suggested that, given the decline in cognitive function, it may be advisable to design a robot in a way so that it is recognizable to a person afflicted by dementia, for instance, by having a human-like or animal-like appearance since even a heavily demented person is likely to be familiar with these kinds of gestalts. This suggestion is backed up by numerous scientific studies that show that anthropomorphic design features make behavior and functionalities of a robot easily recognizable and are often responded to in an anthropomorphic fashion as well (e.g. Nass, 2004, 2010). In contrast, in a focus group meeting at the elderly care facility, the caregivers who know the residents very well (professionals and relatives), as well as the two residents who were presented, jointly expressed their preference for a non-anthropomorphic design. The point here is not whether someone is right and someone else is wrong, but that different stakeholders involved may compete in defining the needs and preferences for vulnerable populations.

As far as involuntary responses are concerned, the same applies to designs for the general population; for instance, people have been found to respond to anthropomorphic designs in anthropomorphic ways, depending to some degree on whether they have time to consider their choices or not (Fussel et al., 2008). Thus, scientific studies can reveal user preferences that they may not be aware of themselves or even deny when asked about them.

To sum up, the complexity principle P3 turned out to be highly fruitful for use case development because it led to thorough discussions of who exactly the stakeholders are, who really benefits from the robots and who might not, what effects the placement of a robot for the interrelationships between stakeholders may have, and lastly, that stakeholders’ perspectives can differ considerably and lead to competing design recommendations, where focusing on one perspective may have potentially crucial consequences from other perspectives.

4.4 The Context Principle P4: What are the relevant contextual features?

The context principle draws attention to the fact that human-robot interactions, besides in the lab, usually take place in rich real-world environments and societal context. Here we can distinguish between the local context in which the interaction happens, the work flow and activities that the robot takes part in, and the larger societal context.

4.4.1. Local context: Robots sharing space with people

For robots, taking context into account is a huge challenge, given robots’ current sensory and reasoning capabilities. However, in order to share social spaces (such as a corridor, a kitchen or even a living room) with humans, robots need to understand how to act appropriately in theses spaces in order not to be in the way all the time. With respect to the SMOOTH use cases, the robot crucially needs to take the shared space and the activities in it into account. For example, when the robot follows the caregiver into a resident’s room, it should not block the door when caregiver and resident are trying to get out. When it is waiting for the resident to get dressed and ready for lunch, it should not linger in front of the wardrobe and respond in a timely fashion to the resident’s attempts to shew it away. From a robotics perspective, this involves specific technical challenges, such as understanding human activities and track them over time. The robot has to recognize reoccurring 3D shapes, objects, people and activities. Moreover, it needs control mechanisms which exploit these structures to yield adaptive behavior for real world environments and manipulation functionalities that let it interact with its environment. Furthermore, interactions with humans also constitute a considerable challenge, such as enabling speech interaction that is robust to ambient noise.

At the same time, in order for a robot to take part in social interaction, that is, share social spaces with people, people need to know what the robot is up to. Humans have developed very sophisticated means to indicate what they intend to do next, for instance, where they are going, using eye gaze, body orientation and speed changes, for example, to signal their intentions (e.g. Mondada, 2009), and they find robots that do not indicate that they see them and take them into account during approach to be creepy and dangerous (Lohse et al., 2013; Fischer et al., 2016). Thus, robots need to employ social cues to signal where they are going and whether they perceive people and obstacles on the way. Jensen (2018) shows in a number of studies that the more robots signal that they perceive aspects of the context, the more positively the robot is perceived and the more it is taken as a serious interaction partner. This may be particularly challenging in the SMOOTH project, given the limited signaling possibilities of the robot and given the limited perceptual capabilities of the residents in the elderly care facility.

To some extent, these issues can be solved by means of technical development, but they also concern the interrelationships between a particular robot and a particular environment; for instance, in a hectic environment, the same robot may be less welcome than in a quieter context (see Mutlu & Forlizzi, 2008).

4.4.2. Robots in a societal context

The relevant local contexts and stakeholders are similar across the three use cases since all address the practice of professional caring for the elderly. Given the holistic nature of this practice, failure to accomplish certain tasks properly in one case may have repercussions in other cases. We can, however, note a difference between the drink serving and guiding use cases on the one hand, and the laundry and garbage collection use case on the other, since the former are more directly constitutive of the caring practice than the latter in which the robot is merely assisting the caregiver. The stakeholders include in all three cases (i) the care-receivers (including those of their relatives who represent their interests), (ii) the care-givers (who have to interact with the robots and whose practice will be affected), (iii) the nursing home managers (who have to decide how to redistribute resources if the robots are introduced), (iv) and society at large, who should be deciding what is permissible or impermissible in this realm and how collective resources should be prioritized. The context of employment of the robot is thus directly connected to a societal discussion of values.

Much work in HRI has shown that interactions are influenced by culture (e.g. Rehm et al. 2018; Fischer et al., 2019), and attitudes towards robots in elderly care are likely to be different across cultures (see, for instance, Robertson, 2017). While the SMOOTH use cases were specifically developed with and for a Danish care facility, if the SMOOTH robot were to be employed internationally, cultural specifics would have to be taken into account both in the use case development process and in the robot design.

The context principle draws attention to the situatedness of robots in human space on the one hand and to the broader societal context on the other. Since society mainly consists of people, much of the discussion of societal context has been addressed by means of the complexity principle already; however, if the context principle is discussed by an even broader interdisciplinary or international consortium, the principle may yield fruitful discussion. It should also be noted that the context principle was introduced to protect users and stakeholders—especially institutions—against ‘technology dumping’: all too often new technologies are dumped into an application context to fulfill some innovation management goals without considering the time *after* the onsite-test, i.e. the period from delivery to routine use (e.g. Bajones et al. forthcoming).

4.5 The ‘Values First’ Principle P5: Does the application realize values in ways humans cannot?

An important issue in value-driven design is the question whose values are to be taken into account and how to weigh them against each other.

4.5.1 Competing values

An example for a discrepancy between values is the SMOOTH drink serving use case; from an interactional perspective, it would be good if the robot could offer drinks by displaying the drinks available while interacting with a resident (as indicated in Figures 1 and 4; see section 4.1.2). However, if the robot carries the load on the back, only three wheels are necessary, rendering one (expensive) laser-range finder in the front above the single wheel sufficient (as in the current design, see Figure 2). This reduces the cost for the robot and hence makes the robot more attractive for municipalities to acquire. Similarly, again concerning the drink serving example, let’s imagine that the robot fulfils the task perfectly to serve drinks and to engage residents between meals in such a way that they socialize more and thus that new value is created. This comes at the price that caregivers have less overview of how much residents have had already, what they like to drink, how they like to drink it, and there has been less opportunity for caregiver and resident to chat with each other. Thus, each value has to be balanced against other values, even if all are generally positive. Careful and extensive deliberation on how the different values are compared against each other is a constitutive ingredient of the value-driven ISR approach.

4.5.2 The non-replacement maxim in a broader societal context

Regarding the non-replacement maxim, the aim of the use case development in SMOOTH is to focus on those tasks for the robot to take over that do not involve so much interaction between caregiver and resident anyway, such as laundry and garbage collection; the hope is that caregivers are freed from repetitive, time consuming or organizational tasks in order to have even more time to spend on high-quality interactions with the residents.

This reasoning responds to projections of demographic change and cost considerations that are based on the societal status quo. In particular, the global population is aging at an increasing pace such that the share of people aged 65 years or above will double or even triple in many countries (Lee et al., 2017). This demographic development imposes challenges not only for the pension schemes but also for the welfare domain, in particular since the share of people aged 80 years or above is projected to grow as well. This part of the population is likely to have an increased demand for welfare services, for instance due to an increase in multi-chronic conditions (Kirchberger, 2012). Therefore, the current solutions for providing welfare services may not simply scale to the future demands.

Robot technology is considered to provide opportunities to mitigate the challenge caused by demographic change and to provide benefits for various types of stakeholders, including patients, caregivers or clinicians and insurers (Riek, 2017). Despite substantial technical advances, robots are still rarely implemented in the welfare domain, compared to other areas, such as manufacturing. This is presumably caused by robotic solutions often not being cost efficient and not being adapted to the needs of the primary users (Andrade, 2014).

To arrive at a commercially viable robot solution, there are two possibilities: Either the robot is able to provide a service that increases the wellbeing of residents of elderly care facilities that humans are not able to provide and which is still in the available budget range of the care institution; or the robot takes over some of the staff's tasks in a cost-efficient way. The three use cases in SMOOTH focus on the second option: The robot being built is neither able to do tasks better than the staff nor is it able to perform tasks that the staff is not able to perform; instead, it supports them in selected tasks to free them for those tasks that involve human interrelationships the most.

To calculate the cost efficiency of the robot, the actual cost for the staff, who perform these actions, is calculated. An advantage of robots is that they can work 24 hours for seven days a week (except for the time slot in which they recharge their batteries or are out of order). The three use cases in Smooth had been selected for maximal impact on an intermediate time scale. We calculated the time consumption for our three use cases in a typical elderly care home in Denmark with around 50 residents in a co-operation with the elderly care center in Køge/Denmark:

- Logistics of laundry and garbage transportation: 19.2 hours per day;
- Serving water: 8.13 hours per day;
- Guiding people: 4.2 hours per day.

If we assume that a robot costs 7,000 DKK per month (including maintenance), and the care institution leases three robots and hires one caregiver to aid the performance of the robots and facilitate services, we arrive at a cost reduction of more than 1 mill. DKK per year (ca. 135.000€) for the institution if all three use cases can be addressed by the same robot. In Denmark, there is room for approximately 40,000 elderly residents in different types of care facilities. If we expect 50 residents on average for each institution, we can calculate the total savings on the basis of 800 institutions to amount to more than 800 mill. DKK per year.

Whether such a saving can be achieved, still needs to be demonstrated; it will depend on, for example, whether all three use cases can be addressed with one robot. Furthermore, for the water delivery service, it was observed that the residents prefer different kinds of beverages, which increases the complexity. Thus, cost considerations may suggest to design the robot also for other scenarios of application; for instance, serving drinks may also be relevant for conference receptions and the like.

From the perspective of the non-replacement maxim, it thus appears that the SMOOTH use cases violate the maxim that *social robots may only do what humans should but cannot do* since for reasons of cost efficiency and potential shortage of care personnel, the robot will take over tasks currently done by human caregivers, and it is possible that the introduction of robots will lead to decreased levels of residents' well-being either by damaging the relationship between human care-giver and care-receiver, or by failing to provide the same quality of empathic touch and care. But suppose, for example, that there was a severe shortage of qualified labor in the professional care sector and that this shortage could not be remedied by allowing foreign workers into the country since the political coalition in power is strongly opposed to this. In this hypothetical situation, the "cannot" in this maxim is, at least in the context of public health ethics at issue here, a practical or socio-political "cannot". In such a case, the non-replacement maxim is not violated.

The hypothetical situation is not so far-fetched, since in Denmark, the lack of qualified workforce is particular acute in the elderly care sector, with 73% of the municipalities reporting a lack or a grave lack of qualified labor (FOA, 2018, pp. 4). The formulation of the non-replacement maxim is intentionally vague (Seibt et al., 2018) in order to engender a debate, within the developer team but also within society at large, about which sense of ‘cannot’ shall apply--is it ‘cannot’ in the sense of the humanly possible or in the sense of the practically possible? Whether immigration policies or the prioritization of other political values can justify the introduction of robots in elderly care depends in part on its effects on the well-being of the relevant care-receivers.

The non-replacement principle has also a heuristic function. It invites us to search for new *ways* of performing the desired action; for instance, in the guidance scenario, the robots could be endowed with special functionalities that a human guide cannot offer (at least not without other assistive technologies)—for example, to project a resident’s favorite pictures onto the wall during the walk, as goal points to increase the resident’s motivation.

4.5.3 Designing for new values

One issue which may easily be neglected is that it sometimes cannot be foreseen what new values a technology may acquire once it is on the market. For instance, the drink serving use case targets a novel social scenario that would add extra value by creating social interaction where otherwise residents would disappear into their private rooms between meals. Such novel opportunities for socializing around robots have been observed, for example, by Lee et al. (2012). In this study, people gathered in the rooms of those people who had signed up for a study in which a snackbot brought some snacks, thus turning the snack delivery to one user into a regular social event for everyone on the same corridor. From this perspective, it can sometimes not be entirely foreseen how robots will be perceived and integrated in users' lives and how they will create new, unplanned-for values.

5. Discussion

The aim of trying to apply the approach of integrative social robotics to the SMOOTH use cases was to (i) explore which, if any, advantages the ISR approach can offer for robotics development beyond the more mainstream user-centered design approach (and possibly other user-oriented methodologies), and (ii) test the applicability of the ISR approach as rule set rather than as praxis, outside of the research and development context in which it is currently being worked out.

To begin with (i), by temporarily expanding the interdisciplinary scope and by eliciting direct responses to the five ISR principles, the ISR approach generated several important insights that directly translate into tasks and decisions about functionalities and design of the SMOOTH use cases.

First, experts and developer team agreed that the focus away from the robot and onto the interactions engendered by the robot is fruitful but immediately complicates design tasks. Many interactions are principally possible with the same robot, but design affords some interactions more easily than others. Not only the functionality of the physical features but also the rich semiotic field that they carry influence how we experience an interaction with a robot. For this reason, it appears questionable whether the initial idea of a multifunctional robot can be maintained.

Second, the differentiation of perspectives called for a clarification of who the primary users are (the elderly who will interact with the robots versus staff and municipalities, if costs are saved). This made power constellations visible that a user-centered design approach does not directly address and capture. The discussion of the complexity principle served to work out in greater detail what can be gained when we look at the use cases from the second person perspective and ask: what kind of ‘thou’ for the robot will the resident take herself to be? Will she feel degraded or privileged in being a ‘thou’ for a machine?

Third, the differentiated responses of the expanded developer team suggest that the contextual embedding of the use cases is clearer in view. However, it is still unclear which of the many contexts the developers should pay most attention to.

Fourth, the responses clarified in detail the way in which cost considerations and (ethical) values (of care) may clash. Here the discussion along the lines of the five principles proved helpful to make the different considerations visible and to put them on the table for a broader societal discussion.

Let us turn then to the question (ii) what the responses to the five principles indicate about the applicability of the ISR approach. In its original formulation (see the quality principle, P2), it is a constitutive feature of ISR that developer teams with maximal (as maximal as possible) relevant interdisciplinary expertise are formed at the beginning of the development process and collaborate on the production of the new interaction throughout the entire process (including its practical entrenchment in the application context). As we noted above, the way in which ISR was used in the application to the SMOOTH project deviated from this requirement. In consequence, the experts’ responses draw attention to the fact that the five principles leave open questions in at least two regards.

First, as the discussion of the quality principle (P2) indicates, the principle does not offer a concrete recipe according to which one could identify and *rank* the types of expertise relevant for the application. Second, the ‘values first principle’ (P5) leaves open questions of axiological ranking, that is, which classes of values (aesthetic, epistemic, ethical etc.)

should be in the foreground. This becomes clear from the discussion of the link between design features and value experience in section 4.1.2, as well as from the discussion of the problem of competing values in section 4.5.1. Precisely what matters most in the given use cases is a matter of debate: Is it privacy, autonomy, dignity, health, well-being at work, sociality or the costs?

In view of the fact that the principles of ISR are inconclusive as to issues of selection and ranking, one might call for a more precise, quasi-algorithmic formulation of ISR. However, there are, in fact, some fundamental philosophical, value-theoretical reasons that speak against the idea of couching ISR into the form of a detailed manual that can be *applied* to a use case proposal from an external perspective. The current formulation of ISR is based on the ontological thesis that unlike numbers, values do not exist in an abstract, well-defined space and in immutable relationships to each other; the proponents of ISR rather take values to exist *in and by means of* the performance of valuable interactions. This process-ontological conception of values – familiar from the early pragmatists but also from performative accounts of rationality as proposed by Habermas – implies that what matters in a given context, and what should matter most needs to be discovered by the *integrative* engagement of interdisciplinary expertise in a developer team that works as a team from the very first to the last phase of the developmental process. Values, and their relative significance in a given application context, cannot be deduced but must be identified by means of personal judgement and joint deliberation, and this process cannot be abbreviated or left out, as in the given case of the external application of ISR to a use case proposal. It is in the course of the process of joint brainstorming, imagining, field research, problem solving, deliberating, discussing that the right, contextually adequate decisions of axiological rankings of values for the given use case will be found. Values are constitutively ‘in-the-making’ – somewhat paradoxically, they are both what guides human judgement in concrete decisional situations and what is realized in these decisions and ensuing actions. Values cannot be deduced, they are arrived at by *judgment* in the technical philosophical sense, a distinctive cognitive posture that requires personal practical immersion in the situation.

While a process-ontological or performative conception of values is arguably, from a philosophical perspective, the most convincing account, it does not sit well with the mental templates of 'formula and application' or 'program and execution' that often guide the thinking of engineers. In addition, as illustrated by the discussion of cost efficiency, from the engineering point of view, the radical reorientation towards a values-first approach is not immediately attractive. From this perspective, there are good reasons to defend the SMOOTH use cases against the 'values-first' principle – utility-driven technology may be inescapable given demographic developments.

If ISR had been applied in SMOOTH from the start, the tension between cost considerations based on the status quo in the political discussion on the one hand and the values-first stance taken would have needed to be productively resolved in discussion between the experts. The no-replacement principle suggests the basic idea that ISR challenges us to use technology only where it is necessary. Abstractly viewed one cannot determine whether the one or other position is on the right track – it is the concrete engagement in the situation in which the right procedure will emerge. In other words, the no-replacement principle is primarily an invitation or challenge for deliberation – it serves the purpose to force developers to reflect their fundamental premises before the use case design and to begin with the basic question of precisely why the technology is indispensable in the given case and which surplus value (not advantage) it can introduce.

The results of the discussion have some implications also for the SMOOTH project: In general, the participating engineers realized (a) that creating social robotics applications in society generates new responsibilities—in ethical, aesthetic, cultural, and scientific regards—that they (nor the users at the location) are not trained to address, and that (b) extending the research teams with experts in the relevant sciences and humanities could relieve them of these responsibilities. Concretely, the discussion of principles P1 and P5 showed, for example, the need for a compensation for touch by means of, for example, the robot singing a song or showing images of children and grandchildren, since because of safety concerns, robots cannot provide human touch, for instance, in the guiding use case. Furthermore, principle P2 invited the SMOOTH team to consider whether the interdisciplinary scope of the consortium was complete or whether the inclusion of additional expertise, for instance, concerning the neuropsychological, ethical, and aesthetic dimension, would be necessary and what the cultural implications of the use cases really are.

6. Conclusion

We can conclude that the exercise of adding a discussion of the five principles of the ISR approach to a user-centered design approach to use case development provides value beyond the user-centered approach; furthermore, we have illustrated how the discussion of the five principles can inspire a general societal discussion suited to bridge the gap between robot development projects and ethical consideration. Taking an ISR perspective can thus prove highly valuable during robot use case development. On the other hand, the full effect of the ISR can only be expected if the approach is implemented as prescribed by principle P2, with the continuous engagement of all relevant experts throughout the development process. Only in the course of such a joint team effort, where expertise from various different disciplines is integrated in the joint search for solutions, experts can use their faculty of judgements, and the right course of action can emerge.

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[1] www.smooth-project.org

[2] See, for instance, the self-description of one of the field's most important scientific journals, the Transactions in Human-Robot Interaction: https://thri.acm.org/editorial_charter.cfm