Robotics in Care Services:
A Finnish Roadmap

ROSE consortium (full list of contributors at the end of document)

Executive Summary

Summary in Finnish on page 4.

In Finland, as in many other European economies, elderly people prefer to continue their independent living at home as long as possible. To support this trend of "ageing in place" and still preserve the quality of elderly care, robots and other new ICT-technologies will enable innovative help in organizing daily activities.

The public discussion on the use of robots in care is lively. However, the ROSE project (Robots and the future of welfare services) consortium discovered the need of an overview of the opportunities and challenges in the Finnish context, based on available knowledge from Finland and abroad. The purpose of this roadmap is then twofold, to inform the discussion as well as to engage in the debate.

This roadmap is focused on the use of robotics in care and promoting independent living with a focus on the elderly population. Applications on robotics in care are divided into four areas: supporting workforce in care, rehabilitation and prosthetics, personal physical support, and personal cognitive/social support. Medical robots such as robotic surgery are outside the scope of this work.

The main aim of this roadmap is to chart the opportunities of robotics in supporting high-quality elderly care in a 5-10 year perspective. In addition to technological opportunities, the roadmap aims to discover necessary conditions for the adoption of robots, considering both the care service system and individual person level factors. The roadmap is focused on care services in Finland.

To support care workers in healthcare institutions, we foresee opportunities in well-defined tasks such as hospital logistics, patient transfer and administering medication. Telepresence (possibly robotic) will become available. Within rehabilitation and prosthetics, robot assisted therapy and rehabilitation exercises will become available. Robotic prostheses will be used for assisting upper- and lower-body mobility.

In personal assistance, robotic mobility aids will become available. New single purpose domestic robots for purposes such as cleaning and personal hygiene will appear. Social and cognitive assistant robots will support communication between humans and provide information services such as reminders. Robots will also be able to provide some forms of cognitive therapy for example to treat early dementia. General purpose assistive robots are not foreseen in the next 10 years due to immaturity of the technology.

The Finnish business and innovation ecosystem around robotics in care is immature. There is no credible, skilled national operator that could connect care technologies, related services and service users. At present, the business ecosystem is still largely at the birth stage, and the wider innovation ecosystem is immature and essential stakeholders are missing. However, Finland appears to possess good opportunities to build a functioning innovation ecosystem around care robotics, as the well-established Finnish technological and welfare systems form a synergic platform for actors and stakeholders to co-operate, allowing both public and private institutions as well as developers and users to participate in planning of robotic services. In order to reach a cutting edge position in using and producing robotic systems in care services, a systematic and multidisciplinary research, innovation and education program is needed.

Even though there are experimental studies on the effects of robots, the impacts of the adoption of robots in care are currently not well known. Larger scale and longer term pilots in real-life environments that are able to show economic and societal impact widely will be needed.

Integration of technology into care services is challenging from investment and regulation perspectives, among others. The care provision is in change due to the current reform of social and healthcare services in Finland. This creates an opportunity for adoption of new approaches since the change may also facilitate the integration of robots with other care technologies, systems and processes. The reform can also pose challenges for the adoption; this roadmap aims to present multiple points of view for the reform process and discussion around it.

Acceptance of robots in care varies widely depending on the main application. For example, acceptance of support robots for hospital logistics is high, but social companion robots pose significant ethical and social questions. Also in general, the more a person has personal experience of robots the higher the acceptance. Formation of personal experiences should be promoted through pilots and the user studies should be communicated to the general public. Moreover, there should be a systemic and systematic focus on users' role in the adoption of care robots. User needs and their involvement should have a true impact in the different activities of the innovation and business ecosystem.

Tiivistelmä

English summary on page 2.

Suomessa, kuten useimmissa muissa Euroopan talouksissa, vanhukset haluavat jatkaa itsenäistä elämäänsä kotonaan mahdollisimman pitkään. Roboteista ja muista uusista tieto- ja viestintäteknologioista on kaavailtu apua päivittäisiin toimintoihin, jotta "kotona ikääntyminen" helpottuu ja ikääntyneiden terveydenhuollon laatu voidaan säilyttää.

Julkinen keskustelu robottien käytöstä hoivassa käy vilkkaana. ROSE-hankkeen (Robotit ja hyvinvointipalvelujen tulevaisuus) konsortio on havainnut tarpeen luoda yleiskuva mahdollisuuksista ja haasteista suomalaisessa kontekstissa, perustuen käytettävissä olevaan tietämykseen Suomesta ja ulkomailta. Tämä tiekartta vastaa tuohon tavoitteeseen. Tiekartan tavoite on kaksitahoinen, tuoda faktoja ja näkökulmia keskusteluun sekä osallistua siihen.

Tiekartta keskittyy robotiikan käyttöön hoivassa ja itsenäisen elämisen edistämisessä, keskittyen ikääntyneeseen väestöön. Hoivassa käytettävien robottien sovellukset voidaan jakaa neljään osa-alueeseen: hoitohenkilökunnan tukemiseen, kuntoutukseen ja proteeseihin, henkilökohtaiseen fyysiseen apuun, sekä henkilökohtaiseen kognitiiviseen / sosiaaliseen apuun. Lääketieteellisiä robotteja, kuten robottikirurgiaa, ei käsitellä.

Tiekartan päätavoitteena on kartoittaa robotiikan mahdollisuuksia ikääntyneiden itsenäisen elämän ja korkealaatuisen vanhustenhoidon tukemisessa 5-10 vuoden aikajänteellä. Teknologisten mahdollisuuksien lisäksi tiekartassa pyritään tunnistamaan edellytykset robottien käyttöönottamiseksi ottaen huomioon sekä hoivapalvelujärjestelmä, organisaatiotaso että yksilötaso. Tiekartta keskittyy hoivapalveluihin Suomessa.

Terveydenhuollon ammattilaisten työn tukemiseksi robotit tarjoavat mahdollisuuksia hyvin määritellyissä tehtävissä, kuten sairaalalogistiikassa, potilaiden siirrossa ja lääkkeiden jakelussa. Etäläsnäolo (mahdollisesti robotilla) tulee saataville. Kuntoutuksen ja proteesien alalla voidaan käyttää robottiavusteisia kuntoutusharjoituksia. Robotisoituja proteeseja käytetään avustamaan ylä- ja alavartalon liikkuvuutta.

Henkilökohtaiseen apuun liittyen saataville tulee robotisoituja apuvälineitä kuten ns. älykkäitä pyörätuoleja ja rollaattoreja. Uusia yksittäisiin käyttötarkoituksiin tarkoitettuja robotteja tulee saataville esimerkiksi siivoukseen sekä auttamaan henkilökohtaisessa hygieniassa. Sosiaalisesti ja kognitiivisesti avustavat robotit tukevat ihmisten välistä viestintää, tarjoavat tietoa ja opastusta, vastaavat kysymyksiin sekä tukevat arjen sujumista esimerkiksi muistutuksilla. Robotit voivat myös tarjota kognitiivisiä harjoituksia, esimerkiksi harjoituksia, jotka voivat olla hyödyllisiä varhaisen vaiheen dementiaa sairastaville. Yleiskäyttöisiä avustavia robotteja ei nähdä seuraavien 10 vuoden aikana johtuen teknologian kypsymättömyydestä.

Suomalainen liiketoiminta- ja innovaatioekosysteemi hoivarobotiikassa on kehittymätön. Uskottavaa, ammattitaitoista kansallista operaattoria, joka voisi yhdistää hoitotekniikat, niihin liittyvät palvelut ja palvelun käyttäjät ei löydy. Liiketoimintaekosysteemi on suurelta osin vasta syntymässä, laajempi innovaatioekosysteemi on kehittymätön ja monet olennaiset sidosryhmät puuttuvat siitä. Mahdollisuudet rakentaa toimiva innovaatioekosysteemi hoivarobotiikan ympärille näyttävät kuitenkin hyviltä Suomessa, sillä vakiintuneet teknologia- ja hyvinvointijärjestelmät muodostavat synergisen alustan yhteistyölle toimijoiden kesken, mikä mahdollistaa sekä julkisten, yksityisten että kolmannen sektorin toimijoiden sekä kehittäjien ja käyttäjien osallistumisen robotiikkaan liittyvien palvelujen suunnitteluun. Johtoaseman saavuttaminen hoivarobottien käytössä ja tuottamisessa vaatii järjestelmällistä ja monialaista tutkimus-, innovaatio- ja koulutusohjelmaa.

Vaikka robottien käyttöä on tutkittu empiirisesti, niiden käyttöönottoon liittyviä laajempia vaikutuksia tunnetaan vielä huonosti. Ymmärrys taloudellisista ja yhteiskunnallisista vaikutuksista vaatii laajempia ja pitempiaikaisia kokeiluja todellisissa käyttöympäristöissä.

Tällä hetkellä teknologian integroinnissa osaksi hoivapalveluita on useita haasteita mm. investointi- ja regulaationäkökulmista. Hoivapalvelujen järjestäminen on muuttumassa Suomessa käynnissä olevan sosiaali- ja terveydenhuoltopalvelujen uudistuksen vuoksi. Muutos tuo mahdollisuuksia uusien lähestymistapojen käyttöönottoon, kenties helpottaen robottien integrointia muihin hoivateknologioihin, järjestelmiin ja prosesseihin. Muutos voi kuitenkin sisältää myös haasteita tässä suhteessa; tämä tiekartta pyrkii osaltaan tuomaan moninäkökulmaisuutta muutosvaiheeseen ja sen pohdintaan eri tahoilla.

Hyväksyntä robottien käyttämiseksi hoivatehtävissä vaihtelee suuresti tehtävän mukaan. Esimerkiksi robottien käyttö sairaalalogistiikassa hyväksytään melko laajasti, mutta robotti sosiaalisena kumppanina on eettinen ja sosiaalinen haaste. Omakohtainen kokemus roboteista lisää usein robottien hyväksyntää. Tästä syystä henkilökohtaisten kokemusten muodostamista olisi tuettava kokeiluissa ja käyttäjien kokemukset tulisi tuoda suuren yleisön tietoon. Käyttäjien rooliin käyttöönotossa tulisi keskittyä systeemisesti ja systemaattisesti. Käyttäjien tarpeilla ja osallistumisella tulisi olla aito vaikutus innovaatio- ja liiketoimintaekosysteemien toimintoihin.

Contents

1. Introduction to Robotics in Care Services

1.1 Why this roadmap?

There are currently two parallel revolutions taking place in post-industrial societies such as Finland: 1) the enormous growth of demand in welfare and health services and 2) the emergence of a new generation of cognitive robots. While the recognition of this demand is timely, future developments and changes within welfare and health should not be underestimated. How and to what extend changes will occur is difficult, if not impossible, to predict. It is therefore imminent to investigate what outcomes are possible and how society can support these. One approach, that is adopted throughout the developed western world, is to investigate how the next generation of robots can assist in services for care, and how they can not. As subtle differences between countries and cultures can lead to different requirements and outcomes, we approach these developments from the point of view of Finland. This means that while the overview and future directions might tend towards a global (or European) trend, the innovation and business ecosystem as well as the care services provision in our analysis is strictly centered around Finland.

Robotics for care are believed to hold great potential for increasing the productivity of health care and welfare service provision, improving the quality of services, through the emergence of new business models. With this document we aim to provide an overview and future directions of care services, the technologies that assist such services and how it affects the innovation and business ecosystem.

Our main mission with this roadmap is to inform the discussion as well as to engage in the debate of the opportunities and challenges in the Finnish context. The roadmap will provide recommendations on policy and identify open research directions. In its current form, the roadmap was initiated in the beginning of 2017, and released to the general public and the Finnish government body in June 2017. As a living document, the roadmap will be revised in the future and released on suitable occasions.

Motivated by the aging population, we consider the elderly generation and how they can be supported with technology to live longer independently. Different scenarios are described with claims why and how they would occur. The roadmap has been prepared by experts in a wide range of fields, spanning from the social and care sciences to the technological sciences.

The public discussion on the use of robots in care is lively, even if the applications are still largely non-existent. The policy framework that ensures the technology is utilized in a responsible fashion, however, should be written now.

1.2 Roadmap consortium

The main consortium responsible of devising this roadmap is part of the Academy of Finland, Strategic Research Council funded research project ROSE - Robots and the Future of Welfare Services. ROSE is interdisciplinary and conducts research on how the advance of service robot technologies enables the creation of innovative new products and services and the renewal of welfare services for the aging population. It studies the evolution of services on the level of the individual, institutions and the society, and considers the needs of the users, ethical standpoints, maturity of technology as well as the service system as a whole.

The objective of the ROSE Project is to study how robotics can assist in the creation and remodelling of products and services, and the renewal of welfare services. The project aims towards the co-creation of ethically viable services together with a wide group of stakeholders. The main stakeholder groups of ROSE are care professionals, the organizers of welfare services (from public, private and non-governmental sectors), members of the aging population, their next of kin and their caregivers, robotics and health technology companies and the public sector in general.

1.3 Scope of the roadmap

For the most appropriate definition of a robot for care services, we turn to the tentative definition of a 'service robot' as proposed by the International Federation of Robotics: "A service robot is a robot which operates semi- or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations." In this roadmap we adopt this definition and consider robotic systems relevant for the future directions of care services if they strictly include (physical) actuation capabilities. This means that systems that are passive and only provide sensor-based information are not included, for example, camera-based monitoring systems, wrist-band emergency systems and fall-detection systems. Moreover, only the fields of care and health are considered, which therefore excludes fields such as medical robotics (e.g., the da Vinci surgical system) and industrial robotics.

The typical service scenario that we envision is set around an elderly person living independently at home or in a (semi)-assisted care environment (e.g., a nursing home). The person has good cognition skills and sometimes struggles with activities of daily living, such as basic housework and the handling of objects. The person either has functional mobility or light impairments such that assistive devices can ensure a moderate or high level of independence. Supportive assistance that allows for independent living (e.g., communication to family, reminders for medicine) already comes in a minimal (technological) form by for example mobile phones or medicine reminder systems. To ensure that living independently in the near future remains possible, technologies that currently exist and technologies that will be available in the near future (i.e., 5-10 years) will be considered and investigated in the care service scenarios. Moreover, robots that indirectly support care work, e.g. in nursing homes or hospitals, are considered as well. Indirect support means that the robot is not directly in contact with the person in care, but supports the care work itself. One example is hospital logistics, where a robot can distribute goods autonomously to different departments.

We emphasize, convey and conclude our view with a 5-10 year future vision, and summarize with several policy recommendations. The executive summary offers a concise overview of the whole roadmap, concluding its main points in brief.

1.4 Outline

This roadmap document starts by introducing the care services in Finland (Section 2) and the current state-of-the-art in applications and technologies (Section 3). Following, the innovation and business ecosystem (Section 4) is discussed, emphasizing its current form as well as the challenges in building a wider business ecosystem. Section 5 presents the roadmap and the 5-10 year vision ahead with several alternative scenarios of robots in care, and their responsible road to the future. The document concludes in Section 6 with several policy recommendations.

1.5 Disclaimer

This roadmap reflects the opinion of individual researchers, and not the academic institutions they represent. Future directions in research and practice may change and not be in accordance with the scenarios as devised in this roadmap. The policy recommendations are therefore to be taken as advice, and are not guaranteed to direct services in care as this roadmap suggests.

2. Care services in Finland

2.1. Reforming care services in Finland

In developed welfare states, social and economic risks have been successfully eliminated by means of effective social policies. This is an impressive achievement. Yet, in the context of economic globalisation, demographic change and institutional transformations, we have to rethink the commonalities of the entire welfare system. In the sector of care services, three level transformations can be identified.

First, a demographic challenge of ageing population calls for new types of care services with consideration of better and longer life as well as diversification of needs and consumers' expectations (Niedzwiedz et al. 2014). An increase of healthy life years, increased level of education and improved wealth challenge the quality and forms of care. On a societal level, service providers and organizers must seek efficient ways and means to cope with increasing care needs, shortage of nursing staff and, subsequently, economic pressures. In addition, because of economic and social mobility, an increasing amount of people live alone and far away from their families or relatives and informal care is not available.

There were over 1.1 million people in 2015 older than 65 years in Finland, which was the sixth biggest share among the EU28 countries (SVT 2015 a). About 400 000 of people are living alone (SVT 2015 b; Statistics Finland, 2016). More than half of persons aged over 75 live in single households (Hammar, 2016). There will be 1.5 million people, i.e. every fourth of the Finns, over 65 in 2030 (Ajankohtaista ikäänty-nei-den, 2016). This advocates strategic aims of the national ageing policy to prolong living at home or in alternative housing arrangements like senior houses. At the moment, there is pressure to improve the quality and availability of home care services and to find new ways to provide care at home (Finne-Soveri et al., 2014).

Second, structural changes are taking place in the expectations towards good quality and individualized care services, in the institutional forms of care provision and in the policies reforming and developing care services. At the moment the Finnish government is introducing an extensive reform of health and social services. This SOTE reform aims to produce more cost-effective and accessible services. This is to be achieved by reorganizing administrative regions and increasing competition between public and private service providers. This should also give clients and patients more freedom of choice (Hallituksen esitys sote- ja maakuntauudistuksesta, 2.3.2017). Although the structural change provides an opportunity for new approaches including technologies to be adopted, the new organization of the field is still unclear and at this point it is impossible to identify effects of e.g. the regional organization of the services.

Third, large scale institutional and organizational reforms will be substituted and boosted by development in technological infrastructure. New ICT-technologies like Internet of Things, Big Data and social and service robots based on Artificial Intelligence will necessarily shape rethinking of the social and welfare services. The current SOTE plan for health and social care suggests a mix and integration of public and private care provision systems which not only enable but also demand for innovative organizational and technological solutions. Thus, it is essential to manage these transformations and lead the institutions and organizations of care production from a low road to high road technological solutions. It has to be defined who are the main actors and facilitators of this change.

2.2. From low to high road?

In sociological and economic theory, it is common to make a distinction between a high road and a low road development. The high road strategy means investments on skills, technological progress and institutional advancement at micro-level (enterprises) and macro-level (society) as key elements of innovations and competition. Respectively, the low road refers to strategies of enterprises and countries, which are not able to invest on innovations and where even industrial relations are not so well developed. The high road is often followed by front liners and the low road by late comers. (Milberg and Houston, 2005; Ornston, 2014).

The rapid industrial development of Finland after the WWII has been explained by the late-comer's advantage in applying imported technologies (Koistinen, 1985; Jalava and Pohjola, 2004; Milberg and Houston, 2005). By using and modifying foreign technologies Finnish companies could increase their own knowledge base and move towards original research and development work. This made it possible to reach a head start and become even a technology leader in some sectors of industry such as in pulp and paper industries and later in, for example, communications technologies led by Nokia (Ornston, 2012).

Could this kind of development take place in the social and welfare services too? Finland belongs now to the most educated and technologized nations. Our welfare system and its institutions are well-established and we have achieved a long record of using modern technologies and developing digital innovations. All this can facilitate and support rapid and efficient technological renewal in the care service sector, too. Combining well-established organizational settings with well-developed technological infrastructures and skills could serve a unique platform to develop, prove and apply innovative robotic care practices.

However, in order to exploit this advantage it is important to identify the challenges and critical factors of the ecosystem. A successful SOTE reform may be a remarkable incentive for care service providers to apply the latest technological solutions in their services. However, to enable care technology innovations we need to maintain a balance between "technology-driven" and "care-driven" approaches. Overall solutions in care are characteristically socio-technological ones where the role of clients and users – elderly patients and care professionals – must be taken into account.

The moment to join the international competition in sociotechnical designs for care robotics is favourable right now since the field is globally mostly in its infancy. At the moment several studies have brought up concerns related to the idea of using care robots. Nevertheless, our own surveys and preliminary field tests show that at least in Finland both seniors and professionals have also positive expectations of assistive and social robotics.

2.3. Robots in service provision

The wider use of advanced technologies like care robots depends on the quality and cost of robot technology, social and political acceptance of service robots and innovative capacity of care organizations. The history of technological innovations, in Finland and elsewhere, suggests that a successful use of technology implies open, democratic and consensual adaptation and that this takes place more likely in high road organizations that favour enhancing skills of workers and that are ready to new divisions of labour (Koistinen and Lilja, 1988; Ornston, 2012). Many high-level Finnish health care organizations, like university and central hospitals, have been forerunners in using artificial intelligence in distance diagnostic and assisting robots in surgery. This could happen in social and care services as well. At the moment, telepresence technology has been adopted to home care services in several municipalities. In Helsinki, already one in ten clients in home care receive remote care.

If robots are to be made use of in care services broadly, the nursing staff needs to accept and adopt this novel technology both in home care and institutional settings (Walsh and Callan 2011; Choi et al. 2013). Organizational aspects can be decisive in this process. For example, as our extensive survey for Finnish care workers (n=4000) shows, head nurses have today more experience with robots compared to practical or registered nurses with no managerial experience. Head nurses are also more involved in planning assistive tool purchases in the workplace. Considering these two results, it might not be a coincidence that head nurses have also more positive attitudes towards robots (Turja, 2016).

Technological changes in the organization should be built with different-level workers involved in decision making processes. When healthcare organizations choose their "point of contact" for technological and robotic assistive tools, they should consider other than staff members who already have a supervisor status. Indeed, practical nurses are more interested in such representative posts than for example registered nurses, head nurses and other managers in healthcare (Turja, 2016).

Today, expectations for robotics in care are mainly focused on "low tech" tasks. According to our survey done as a part of the ROSE project, nurses see a need of robotic assistance especially in physically demanding tasks. This includes lifting heavy materials and moving patients. Additionally, current assistive tools made for heavy-lifting are not efficiently used in healthcare. Nurses report assistive tools to be inconvenient to use especially in cramped spaces. This sets up a tough demand for robot developers to design robots both multifunctional and dexterous (Turja, 2016).

Along the development of robotic technology, care services are likely to change in multiple ways and there are different options how to advance towards renewed technologized practices of care. Besides just making incremental modifications in them, the current services can be organized in completely novel ways. There may be also totally new kinds of services which are not known today.

2.4. Care preferences and user needs

In Finland older people prefer living in their own homes ("Ikääntyminen ja asuminen 2012" research). For an older age group (75–80 years) living in one's own home was also the most preferred option (84 %) regardless of possible restrictions to the ability to function. Nevertheless, the older age group considered moving to a sheltered home as a more probable option than the younger age group (65-74 years).

Several European studies report similar results. There is a preference for state-based care over family-based care among those, whose health limits their ability to perform paid work, who do not receive personal care from informal sources and who live in nations with higher long-term care expenditure (Mair, Quiñones & Pasha, 2016).

Finnish and international studies indicate that help is most often needed with washing and bathing, doing light and heavy housework, banking/shopping, doing one's own cooking, cutting own toenails and carrying a heavy load (Hammar, Rissanen & Perälä, 2008). Concerning mobility, around 40–50 % of Finnish home-care clients needed help with moving outdoors and 10–20 % with walking 400 meters and using stairs (Hammar et al., 2008).

Need for help with socializing and loneliness has also been reported widely (Boerner et al., 2016; Hammar et al., 2008). Most often mentioned psychological difficulties that older people face are related to loneliness, lack of autonomy (dependence on caregivers) and fear of falling (Mast et al., 2010). Older people who have been feeling at least some loneliness or depression, reported not having anyone to talk to about their feelings (Somesan & Haragus, 2016).

Older people also often need help with administrative tasks, such as dealing with paperwork, keeping track of financial matters and applying for social benefits (Boerner et al., 2016; Hammar et al., 2008). In addition, older people report on a decrease in overall energy, decreased hearing and eyesight, and forgetfulness regarding, for instance, taking medicine (Mast et al., 2010). Finally, the quality of life of older people could be improved with meaningful activities and unimpeded living environment (Hammar et al., 2008).

2.5 Elderly user perspectives and acceptance of care robots

Although elderly people have various needs for assistance and help, it is not clear if robots or advanced assistive technologies would be accepted in use in elderly care services. In general, Finnish people perceive robots in a positive light. Based on a large-scale European survey (Special Eurobarometer 427, 2015), 65% of Finnish 55+ citizens find robots positively, and 87% of them thinks robots are good for the society as they help people. About two out of five 55+ citizens accept using robots to care for elderly and infirm people. This number is a little lower than for Finland in general, among which almost half (47%) accepts robots in care. Older people tend to be more negative toward robots than younger people. This may be partly related to lack of experiences, knowledge and confidence about technology, or on the other hand, perceived immaturity and uselessness of robots for the special needs of the elderly. In some studies, respondents show high acceptance to robots that help to regain independence if the person is old or handicapped (Arras & Cerqui, 2005), or robots that help in daily household routines or heavy tasks such as cleaning and carrying things at home (Ray, Mondada & Siegwart, 2008). Broadbent, Stafford and MacDonald (2009) conclude that older people are typically less willing to accept robots in general but positive for robots that provide independence. Men and people with higher education tend to be more interested than women and people with lower education.

In a recent Finnish survey for 115 elderly people (Miwa & al., 2017), 80% of the respondents would use emergency call systems to maintain their independent living at home. For other kinds of assistive and robotics technologies – support for walking, hygiene, mobility, carrying things, eating, taking drugs, gaming to prevent dementia, and video calls – the acceptance varied between 40-60%. Telepresence robots were accepted by 17% and social robots by 6%. Only 4% of the respondents would take nothing of the technologies into use. The results must be taken as indicative as the data is small, and does not allow to make conclusions about Finnish elderly in general. However, the data seems to confirm that the more familiar the technology is – emergency call systems are in wide use in elderly care – the better it is accepted. Getting first-hand experiences and understanding of the benefits of care robots is important in increasing their acceptance.

Social robots, i.e. robots that are developed mainly for social communication and interaction, are a special case of care robots. Social robots are evaluated by both in terms of their functionality (usefulness) and capability as a social, communicative partner (Heerink & al., 2010). Even if attitudes towards social care robots may be low (cf. Miwa & al., 2017 above), several studies show that social robots are able to raise positive feelings in people, including elderly people with dementia (Melkas & al., 2016; Niemelä & al., 2016), and that older people are willing to talk with robots (Vandemeulebroucke & al., 2017) and even build relationship with social robots (de Graaf, Allouch & Kramer, 2015). On the other hand, there is an underlying fear among many that introducing social robots to elderly care leads to decreased human contact and social isolation for elderly people (Vandemeulebroucke & al., 2017; see also Laitinen, Niemelä & Pirhonen, 2016). These results indicate at least that social capabilities of care robots can be a benefit if carefully designed, but care services should be arranged so that feelings of loneliness do not increase.

Two recent review studies (Yusif, Soar & Hafeez-Baig, 2016; Vandemeulebroucke & al., 2017) investigate the reasons and motivation of elderly people *not* to take assistive technologies into use. The most often mentioned issues were privacy (e.g. due to monitoring), trust, functionality/added value, price and maintenance costs, low usability and suitability to everyday use, and no perceived need for the technology. Elderly people could also suspect a risk of becoming dependent of technology and feel lack of training and education, or feel negative about a "stigma of gerontechnology". Social robots that look like toys for children may cause a feeling of infantilization of older adults. However older people may accept robots as a 'necessary evil' because they are beneficial from an economic viewpoint (e.g., Wu & al., 2016).

Finnish perspectives to care robots have also been explored in a deliberative panel for elderly citizens, arranged by the ROSE project with the Institute of Bioethics in Tampere in spring 2017[1], and a survey on the YLE website, arranged by YLE and the University of Eastern Finland in autumn 2016[2]. The 2000 respondents of the web survey were little more negative than positive about care robots, with men being more positive. Routine tasks were better accepted for robots than social robot companion to humans.

2.6. Summary

In Finland, as in many other European economies, elderly people prefer to continue their independent living at home ("ageing in place") as long as possible. Acceptance of possible robotic services is moderate in Finland, several studies indicating that approximately half of the citizens would take care robots into use. Understanding and seeing the benefits of care robots in increasing autonomy and independency of elderly people is one key to increase the probability of large-scale adoption of care robots. Service and care robots together with other new technologies create options to modify and renew care practices that make this possible and which help us to maintain a high quality of care.

Reforming the entire social and health care system is reasoned in economic and political terms, too. One of the main goals of the SOTE reform in Finland is to give equal and regionally balanced access to services for all. The reform also aims at increasing user choice. In this framework, new information and communication technology (ICT) is not only a means to ensure administrative efficiency but it is also a means to enable innovative rearrangements and new tools for service provision.

In order to reach a cutting edge position in using and producing robotic systems in care services, Finland needs a systematic and multidisciplinary innovation and education program for care technology and service robotics. As care receivers like elderly or disabled people can have very different physical or cognitive qualifications, the skills of professional and occupational care givers in managing robotic

[1] http://www.bioetiikka.fi/?p=1052
[2] http://yle.fi/aihe/artikkeli/2017/04/07/kyselymme-hoivarobotteihin-suhtautuminen-epailevaa-miehet-suopeampia

applications should be emphasized. To gain full advantages of robotic systems in care, systematic and multidisciplinary training programs on robotics should be developed also for secondary and tertiary levels of education.

3. Applications and technologies

Modern-day robotic technology is being developed to provide assistance and interaction with people. Regarding care, the main driver behind these developments is an aging population that requires care services, while living either independently or (semi-)assisted. This broad application of environments (from supervised assisted living hospitals to individual homes) causes great demand of the developed technologies when regarding autonomy. When completely supervised, systems are guided by a care-giver and as such, allow for simple designs and interfaces. The greater the level of autonomy, the more careful the design of the system and the interface needs to be in order to operate without any supervision. Additional difficulty is the unstructured properties of environments, as these can range from semi-structured such as hospitals, to completely unstructured such as people's domestic homes. Moreover, robotic systems that are developed for assistance can provide support in many ways (Dahl et al. 2014). Interaction can be physical (De Santis et al., 2008), social (Dautenhahn, 2007) or informative (Goodrich and Schultz, 2007), and involve robotic systems with varying degrees of complexity (Leite et al., 2013). We therefore divide this overview in four assistance categories that describe existing systems: hospital logistics, rehabilitation, physical assistance and cognitive assistance (see Table 1).

Table 1. Overview of robotic support systems

Application areas	Robotic systems	Examples
Robots for hospital (logistics)	Hospital pharmacy Medicine transport in hospital Lifting patients*	(Bloss, 2011) Robear (nursing care robot)
Rehabilitation and physical support	Robot rehabilitation equipment Prostheses External body aid	Resyone (robotic device for nursing care) Lean Empowering Assistant (LEA)
Personal physical assistance	Eating (eg. Robotic spoons) Movement Lifting and carrying objects Cleaning Cooking* Dressing* Hygiene*	Obi (robotic feeding device) Lean Empowering Assistant (LEA) Roomba (vacuum cleaning robot)
Personalized cognitive and social assistance	Self-care support (eg. to move motivation) Partner robots Support interaction (eg. Telepresence) Cognitive support (eg. reminders, finding objects*)	(Görer et al., 2013) (Dautenhahn, 2007) (Goodrich et al., 2007) (Leite et al., 2013) (Kristoffersson et al., 2013) (Sheridan et al., 2016) (Melkas et al., 2016) (Johnson et al., 2014) (De Santis et al., 2008) (Fischinger et al., 2016) PARO (robotic seal) NAO (small humanoid robot)

		Zora robot (NAO care solution) Pepper (humanoid robot) Care-o-bot (mobile robot assistant)

*marked are not yet commercial

3.1 Robots for supporting workforce in healthcare institutions (e.g. hospital logistics)

Support systems that help care in an indirect way, offer logistic support by automating or assisting in heavy and repetitive tasks such as the transportation of goods (Bloss et al., 2011). The most well-known system, TUG, automates the delivery of goods for pharmacies, central supply, kitchens or laundry. The advantages that such mobile robots offer are the low level of supervision, enabling operation at night times, such that disturbance to personnel and patients is minimized. In similar nature, advances are being made toward robotic devices that assist in lifting patients or elderly in a semi-automated way. Robear (Robear, 2017) is a robotic system developed by the Japanese research institute RIKEN, capable of lifting a person from a bed. The system is not commercially available and is in an early development stage. There are certain challenges associated with these existing systems. First of all, delivery robots need paths that need to be available in premises and which must be taken into consideration in architectural design of elderly homes and institutions. However, they will automate many delivery-based services in the future and are often reasonably affordable. On the other hand, certain tools such as the lifting robots are in their early stages, require large space, are difficult to move from one place to another and are expensive (if even available for commercial purchase). For wider adoption these robots must become more mobile, more light-weight and more affordable.

3.2 Rehabilitation and physical support

Rehabilitation and physical support applies to both lower and upper body function. While upper body rehabilitation mainly aims to the recovery and support of arm function, the lower body can be supported to regain mobility and (re)learn walking. The shift from assistance in recovery, due to e.g., accidents, to permanent walking support for the elderly, is easily made as shown by the product developments by companies such as Hocoma Inc[3]. In Finland several care and health homes offer such rehabilitation support as shown in (Yle, 2017).

Systems that offer support for people with impairments have been on the market since decades (e.g., walking support), and recent developments are increasing their capabilities with technology. One example is the Lean Empowering Assistant[4] that is essentially a walker, but is robotized such that active guidance, navigation and motion (e.g., dancing) are possible. Another example is a robotic system that supports elderly people getting out of bed (Resyone, 2017). Developed by Panasonic, the system, known as Resyone, mechanically transforms a bed into a wheelchair. Common for many of these technologies is that they support performing physical activities that are standard for healthy adults. Technology and systems that aid in movement are therefore slowly moving from a physicians practice to people's homes. For independent-living elderly these technologies are essential to lengthen their independent-living period.

[3] https://www.hocoma.com
[4] http://www.robotcaresystems.com/robot-lea/

This shift from expert-centred care to personalized care allows for tele-care where a physician can video-call to a care-taker and provide advice via a tele-presence system (Kristoffersson et al., 2013). This is another technology branch in rehabilitation and which has been available for some time, but not well penetrated yet to the markets. It is likely that there will be another wave of telepresence tools for interaction between care professionals, customers and their relatives and friends.

3.3 Personal physical assistance

Aging in place is a preferred choice for most elderly people. Technology can support their independence and increase their quality of life by offering physical support. Such support is commercially available and already used in many care homes and trials are ongoing with elderly people in Finland (Melkas et al., 2016). When considering physical support such as eating[5] and walking[6], initial results based on trials with volunteers have demonstrated positive acceptance of such systems.

The robotic embodiment of an assistant for care is often visualized as a mobile robot with manipulation capabilities. Care-O-bot® is the product vision of a mobile robot assistant to actively support humans in domestic environments[7]. The fourth generation of this successful development series is more agile and modular than its predecessors and offers various ways of interaction. Developed by Fraunhofer IPA, it is commercially available as a research platform. Mast et al. present the development and evaluation of 'Hobbit' a socially assistive care robot for older adults, which has the potential to promote aging in place and to postpone the need to move to a care facility. Hobbit is designed especially for fall detection and prevention (e.g. by picking up objects from the floor, patrolling through the apartment and by employing reminder functionalities) and supports multimodal interaction for different impairment levels (Mast et al., 2015).

The above personal physical assistance robots will ultimate provide the "robot servant" service, but these tools are mainly developed in research laboratories, the platforms are expensive and we cannot expect their wide adoption until 5-10 years of active development.

3.4 Personal cognitive and social assistance

As aging impairs cognitive capabilities, technology can be used to assist in for example reminders for medicine, support with exercises (Görer et al., 2013) and easy access to family or medical professionals via tele-presence systems (Kristoffersson et al., 2013). Typically, such support is offered via robotic systems that have an approachable appearance such as the well-known robots NAO[8] and Pepper[9] developed by SoftBank Robotics, and the robotic seal PARO[10].

Personal cognitive and social assistance does not require a physical platform such as a robot, but any "natural user interface" such as Amazon Echo for spoken user interface. However, a robot such as NAO or a tele-presence system such as Double can provide a mobile platform for cognitive and social assistance. This development is now active in the Artificial Intelligence research community and breakthroughs are

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[5] https://meetobi.com
[6] http://www.robotcaresystems.com/robot-lea/
[7] http://www.care-o-bot-4.de/
[8] http://zorarobotics.be
[9] https://www.ald.softbankrobotics.com/en/cool-robots/pepper
[10] http://www.parorobots.com

likely to occur within the next 2-5 years. Current examples of these are personal assistants such as Microsoft Iris, Google Personal Assistant and IBM Watson which all currently provide development tools for developers. For elderly care it is likely that these AI software tools and libraries and affordable mobile platforms will generate many interesting products during the next few years.

3.5. Other scenarios of robotization and automation in care

Robots are part of a wider trend of digitalisation and automation of services. To be successful, robots need supporting automation, data, general user interfaces and service and software providers. Robots also need to be integrated in other service and technology infrastructures in the society. Such scenarios are most fruitful when supported and enabled by mass produced equipment and the internet.

Hospital and dormitory logistics: Versions of industrial AGV vehicles take care of parcel, e.g. food and laundry logistics in corridors at "logistics level" allowed for personnel. AGV vehicles pick and deliver items to and from use sites using lifts. Voluntary persons are transferred to and from e.g. laboratory and x-ray with telepresence equipped AGV beds. Logistics designed with the building complex.

Telepresence, wearables and remote health supervision: Person learns to use telepresence with relatives. Voluntary person is equipped with a suitable selection of wearable systems, that measure health related signals – and potentially give medicine or cure. Internet connected device (robot, computer, tablet, smartphone, smart speaker or related) sends data or conclusions to analysis central. The analysis software generate alarms and visualise data. Medical personnel utilise telepresence and direct proactive care.

Parcel and person logistics for longer period at home: Autonomous vehicles transfer parcels (e.g. food, medicines, samples and mail) to homes in rural areas. Autonomous shuttle busses pick persons to laboratories and back home.

Smart home and bed/chair AGV for physically disabled: AGV telepresence bed – transforms to chair – moves person around smart 200 inhabitant dwelling building with service stations and medical care. Telepresence meeting stations, semi-automated spa, restaurants, rehabilitation robots, park routes, etc.

3.6 Discussion

As stated by Demos Helsinki in (Health 2050, 2016), the future of health is more focused on prevention than on cure. A healthy lifestyle is actively promoted and technology and digital services will play a big role in this. As shown by this brief overview, and additionally shown in Table 1, much effort is being spent on developing robotic support systems for the elderly. Besides these individual examples, we conclude by presenting several national (i.e., Finnish) and European initiatives that have as main focus on care, technology and the elderly.

4. Innovation and business ecosystem

This chapter discusses the concepts of business ecosystem and innovation ecosystem in the context of care robotics. In addition, the importance of the concept of living labs for this context is brought up. These concepts all relate to the societal and systemic level of the use of care robots, however with somewhat different emphases.

4.1 Current situation

Based on a study from the Technical Research Centre of Finland (Ruohomäki, 2017), the Finnish care services' business ecosystem is defined as follows: the business ecosystem that works in the domain of care of Finnish elderly people; the network of interdependent agents that knowingly aim at value co-creation. Actors have been identified and depicted in Figure 1.

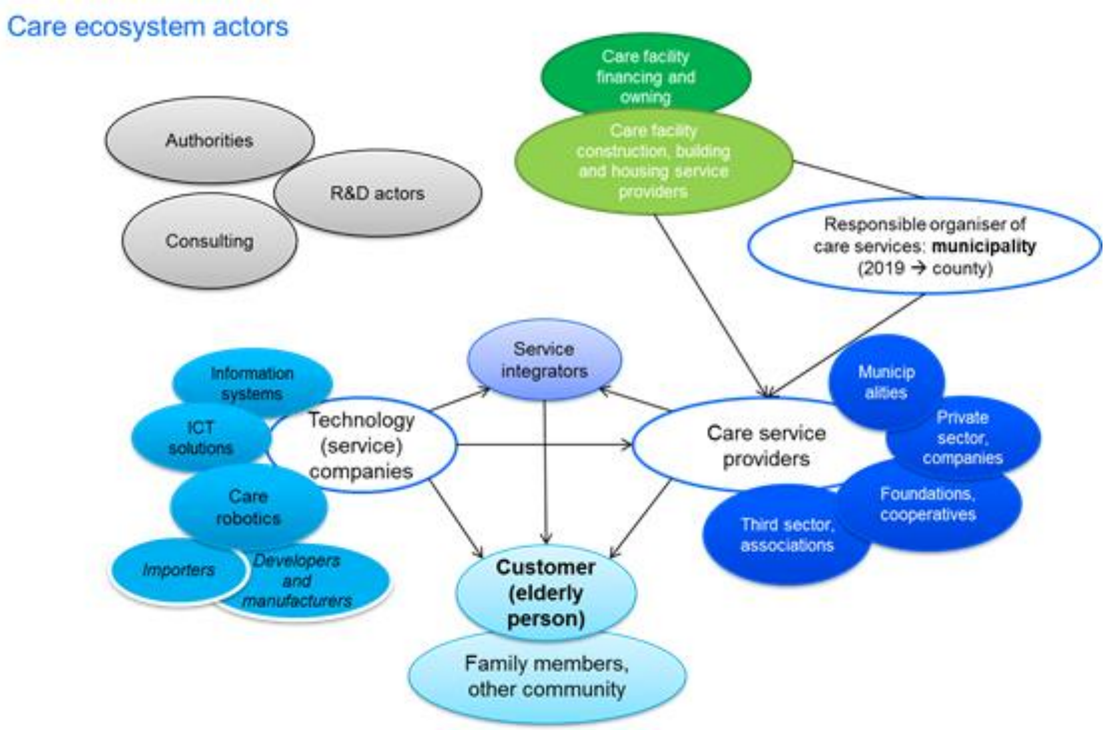

Figure 1. Actors of the business ecosystem of Finnish care services (source: VTT).

There is lots of activity among technology providers in the care service field: the field is "bubbling" with activity at present. For instance, monitoring systems and telecare are piloted and integrated in care more and more, and those technologies are mature. Considering care robotics (service) providers, there are only a few of them, and technologies are partly immature. Their connection to the care ecosystem is still very loose. The collaboration of care robotics service providers in the ecosystem has mainly comprised piloting of care robots in different use environments (care facilities and homes of elderly people) together with R&D actors and technology enterprises. Many of these pilots have been carried out by EPTEK and Forum Virium Helsinki. The pilots have still been quite unconnected to the actual aims of care. Considering wider use and acceptability, robots should be integrated with other care technologies as well as the existing processes and information systems in care. On the other hand, the user and the expected impact must still be more emphasized in adoption of care robots.

As to expectations and prospects for care robots in the Finnish elderly care, VTT interviewed 10 health technology companies about their views on care technologies and care robots, in particular, from the business perspective. According to the interviews, there is business potential especially in care robots supporting elderly people's independent living at home, and in tasks where human contact is not necessary. Safety, alarm and cleaning solutions were mentioned most often. The companies were most interested in robot technologies that are mature and cost-effective, enabling cheap solutions. The companies raised several challenges, too. First, it is difficult to find the right customer or payer due to the complexity of the public administration. Skills in procurement of technology are lacking. There should be a clearer administrative model and an actor clearly responsible for procurements. Second, companies need research data to support their solutions and sales: wider-scale impact studies to justify technology solutions. Those are needed especially when entering international markets. Present pilots are too small and unsystematic. Longer-term, well-designed (before - after) studies with a sufficiently large number of users are needed. Third, the business field is fragmented and companies are small, especially for international markets. Many still pursue their own advantage only, and there is no maturity for ecosystem level collaboration. There is no credible, skilled national operator that could connect care technologies, related services and service users (see also Chapter 2). The SOTE reform, when finalised, should provide a clear responsibility model for procurement of holistic solutions, and support a new, larger perspective for considering care technologies and renewal of care practices and operational models (see also Chapter 2).

Procurement issues, problems in integration and lack of holistic views have been brought up in earlier studies concerning other types of wellbeing technology (Melkas, 2008; 2013; Melkas & Pekkarinen, 2014). The situation is similar nowadays, but technologies are increasing at a higher speed and becoming more varied, further highlighting the urgent need to deal with these issues. Care providers that take new technologies into use also face risks, as the small robot companies may end up closing down; who then provides maintenance and support for use? What should be done about this? In Japan, care providers are supported by the government when purchasing robot technologies. Should that be introduced in Finland, too? This is one question closely related to bridging technologies and care as well as developing the business ecosystem. In the following, the perspective will be shifted towards the wider innovation ecosystem.

4.2 Towards a wider innovation ecosystem

In Finland, there appear to be good opportunities to build a functioning innovation ecosystem around care robotics because of a long tradition in extensive welfare services for the whole population and technological expertise, inter alia. In the present situation, one may see the first steps of a robot business ecosystem, as defined by Moore (2006); a business ecosystem is ‘a type of a business network, a collaboration to create a system of complementary capabilities and companies’. Firms should not be seen as a part of an industry but as a part of an ecosystem where companies cooperate, compete and co-evolve capabilities around a new innovation (Moore, 1993). The Finnish companies in question are, at present, few and usually small in size, and it does not yet appear appropriate to talk about a value network in which the value is co-created, as ecosystems have also been characterized (Leviäkangas et al., 2014; Peppard and Rylander, 2006). Moore (1993) defined four different stages in the development of business ecosystems: birth, expansion, leadership and self-renewal or death. Reflecting on the Finnish situation, the business ecosystem is still largely at the birth stage.

The wider concept of innovation ecosystem covers various relevant actors in addition to businesses and focuses essentially on, for instance, users. When mapping an ecosystem, one should try to identify the organizations whose futures are most closely intertwined and that share certain dependencies, as ecosystems cross a variety of industries and contain several ecosystem domains (Iansiti & Levien, 2004). The innovation ecosystem thinking is thus, essentially, future-oriented thinking. In the field of robotics, there is space for future business activities that do not necessarily exist yet or are in their early beginnings, as found also in a LUT survey to innovation ecosystem actors (2017, about 250 respondents; analysis ongoing). Users' (covering both older people and their close ones as well as caregivers) role in the future of care robotics in Finland is of utmost importance, as much depends on their acceptance and skills (see also Chapter 2). In addition to the users, the innovation ecosystem needs to incorporate the essential stakeholders from the public and third sectors in addition to the companies.

Defining the ecosystem boundaries is generally challenging (Rinkinen & Harmaakorpi, forthcoming), and there might even be conflicts between the ecosystem's and the individual members' successes (Nambisan & Baron, 2013). The creation of an 'ecosystem mindset' in the near future will be important for the field of care robotics in Finland. This means, at best, that the whole innovation ecosystem perspective would be considered when making strategic choices and decisions within one organization. *In the present situation, the innovation ecosystem is immature and essential stakeholders are missing or not systematically involved.* Collaboration and knowledge are desired by various stakeholders, according to the LUT survey. In addition, *the care system is being renewed, exacerbating challenges in obtaining and maintaining a systemic view of the use of all wellbeing technology including care robots*. The challenges of managing this transformation are discussed in Chapter 2.

4.3 Living labs

Living labs are related to and may contribute in an important way to ecosystem thinking. They are one form of open innovation networks organizing innovation and development activities with new means (e.g. Dutilleul et al., 2010; Nyström et al., 2014; Leminen, 2015). They provide multiple benefits by accessing, for instance, rare expertise and resources and developing them with various stakeholders. Westerlund and Leminen (2011) have defined living labs as "physical regions or virtual realities, or interaction spaces, in which stakeholders form public–private–people partnerships (4Ps) of companies, public agencies, universities, users, and other stakeholders, all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts".

Users have become important sources of knowledge and creativity for innovation in all the sectors (e.g., von Hippel 2005; Nyström et al., 2014; Leminen et al., 2015). The underlying assumption of living labs is that they are real-life environments, where 'accidental collisions of thinking' take place; and such accidental collisions may steer innovation activities towards unforeseen innovation outcomes. Living labs involve users but also other stakeholders at different stages of the innovation process (Ståhlbröst & Bergvall-Kåreborn, 2008; Almirall & Wareham, 2012). User engagement is equally relevant to technological and non-technological forms of innovation (Edwards-Schacter et al., 2012). Although living labs can be strategic and even permanent initiatives and concrete spaces cities and regions, they may also be embodied in temporary network settings in which innovating organisations and users interact to improve existing solutions, products and services or create new ones. They are considered a growing approach in, for example, sustainable urban and healthcare transitions (e.g. Schliwa, 2013; Geenhuizen, 2014; 2015). Benefits of user involvement have long been acknowledged, but users' importance still needs to be advocated (Konsti-Laakso et al., forthcoming).

Most of the health and welfare living labs focus on identifying different health care contexts and explaining interactions between users and other stakeholders (Galbraith et al., 2008; Kanstrup et al., 2010; Lin et al., 2012; Panek & Zagler, 2009; Panek et al., 2011; Brankaert et al., 2015; Brankaert & den Ouden, 2017). Despite the emerging literature on robotics designed for the needs of the health and welfare industry (cf. Wada & Shibata, 2008; Klein et al., 2013; Kachouie et al., 2014), studies on their use in the open innovation model seem to be largely absent. Particularly the use of robots to support innovation in living labs is practically non-existent. Hence, there is a substantial need for research on social and service robots in welfare and health care innovation. Living labs have a strong role in the robot pilots of the ROSE project through Laurea Living Lab Network including Sipoo Living Lab and Lahti Living Lab (coordinated by LUT). Understanding the variety and applicability of different kinds of robots that are used to support health and welfare innovations is essential and can be advanced through living labs. That may aid living lab participants to achieve the objectives of using robots. Companies, public organizations and private organizations may apply social and service robots to design and develop new services when innovation takes place through living labs.

4.4 Summary: Cultivating the systemic view

The Finnish business and innovation ecosystems around robotics in care are immature. There is no credible, skilled national operator that could connect care technologies, related services and service users. At present, the business ecosystem is still largely at the birth stage, and the wider innovation ecosystem is immature and essential stakeholders are missing. However, Finland appears to possess good opportunities to build a functioning innovation ecosystem around care robotics, as the well-established Finnish technological and welfare systems form a synergic platform for actors and stakeholders to co-operate, allowing both public and private institutions as well as developers and users to participate in planning of robotic services.

As living labs essentially focus on users, they potentially have an important role to play in cultivating the innovation and business ecosystems. Different means are needed on different levels, however. Robotics must be effective and beneficial to become more usable. It is vital to take into account the whole of older people's lives, and how the different technologies are integrated, as in the future, robotic applications will be added into other appliances (e.g., rollators) to an increasing degree. Avenues should be found together for how knowledge can be co-created and distributed towards the various stakeholder groups so that true impact on decision-making is also reached. The European Network of Living Labs (ENoLL) could possibly support development in this field more comprehensively. Living labs could also support the companies' needs for wider pilot platforms that would enable longer-term research.

Culture of experimentation has in general been highlighted in Finland recently. In the LUT survey to innovation ecosystem actors, the culture was considered as an important factor facilitating use of robots in Finnish welfare services. That culture can be aided and put into practice through living labs and ecosystem thinking. In ecosystem development, governance support for piloting in order to bridge technologies and care services (funding) would also be needed. ROSE will look into ways of cultivating the innovation ecosystem with its focus on the three essential levels; users, organizations and the society. In addition to its research role, ROSE may in the future also function in the role of a facilitator and integrator of different actors in creating and maintaining the ecosystem (but cannot be responsible for the system's existence).

5. Roadmap and Vision

5.1 Responsible roads to futures

5.1.1 The very big picture: Society-level developments will affect technological changes

Uses of technology will depend on the directions that societies will take. Various ideal-typical socio-political scenarios can illustrate different dimensions in which the future is open.

One much-discussed variable is that of whether robots “will take our jobs”, on which estimations vary. Some estimations suggest that technology has always also created new jobs, other suggest that this time we are facing a qualitatively different change. The estimations have not always been methodologically well supported.

According to a report released by The Oxford Martin School in 2013, 47 percent of total US employment is in the high risk category, meaning that several occupations are potentially automatable over ten to twenty years (Frey and Osborne, 2013). By contrast, one-third of Finnish employment will be highly suscep-tible to computerization and robotization in the next decade or two (Pajarinen et al., 2014). Occupations in health care and social work are not included in the high risk category. However, some work tasks in these jobs are expected to being computerized and systematized in the future due to developments in the technologies of artificial intelligence and cloud robotics. According to Mari Kangasniemi and Cristina Andersson’s (2016) estimation, by 2020, at least one-fifth of the responsibilities of nurses and practical nurses in long-term elderly care facilities can be carried out by automation and robotics (mainly regarding robots for hospital/logistics), although the estimate is debatable. If this estimate is correct, the next question is whether this spared time will liberate nurses to spend more time with their customers as Kangasniemi and Andersson expect. The other possible scenario is that savings within robotics will not be used for the benefits of elderly people but only to increase the profits of service companies or to cut costs of public service providers.

It should be noted that such Frey&Osborne -type arguments try to make predictions about macro-level developments on the basis of micro-level observations, which is methodologically problematic. For sure, there will be irrevocable changes in work practices (contents of jobs, skills needed, organisation of work etc.) and some jobs will be permanently gone, but on the basis of micro level observations it is almost impossible to make conclusions about macro-level developments. The winners and losers of robotization are different groups at micro and macro -levels and in short and long run. The problem is even more complicated when it comes to comparisons between countries.

It is equally difficult to estimate to what extent robotization will create jobs. In the past, technological advances have typically created jobs. However, for example economists Daron Acemoglu (MIT) and Pascual Restrepo’s (Boston University) come to the conclusion that there is little evidence of new jobs being created. A responsible stance seems to be to take seriously the fact that the future of work may be very different compared to the past and present of work in the health care sector.

Other dimensions of large-scale changes include the role of the environment, including climate change. On this issue, too, some views are relatively optimistic (see e.g. European Parliament 2017, §47-48), whereas some are relatively concerned, including the consensus of climate scientists (see e.g. IPCC 2014). In a responsible development of technology, the ecological aspects should be taken into account, and in responsible manners of planning the future, even within 5-10 year frame, the societal upheavals created by climate change should be taken into account.

A third big change concerns the unprecedented rise of inequality in the world. This is noted by European Parliament (2017, sec. K) recommendations on robotics: "whereas in the face of increasing divisions in society, with a shrinking middle class, it is important to bear in mind that developing robotics may lead to a high concentration of wealth and influence in the hands of a minority". Together with the changes in work life, and environment, such changes create pressures towards new kinds of "social contracts". In the development of responsible robotics, one question will be whether it will foster or hinder inequality. Whether the better or worse potentials of technological disruptions will take place will very much depend on the kind of society the development takes place in (see the next subsection on how to assess "better" and "worse" in terms of effects on the quality of life and autonomy of individuals).

In one sense, it is up to politics, in democratic countries the will of citizens, what directions will be opted for in the future. There are alternative futures and it will depend on political and other forms of power (e.g. ideological, economic, military) which will be realized. One way to understand alternatives is to map ideal-typical scenarios, while remaining non-committal about which (if any) of those will be realized. The scenarios can alter from technologically prevented environmental deteriation, with relatively egalitarian societies with meaningful work, to environmental deterioration, inequality and general unemployment (see e.g. Frase 2016).

5.1.2 Questions of Responsibility and Ethics

Good autonomous life is widely accepted as an ethical criterion for assessing the desirability of various technological advances, in the context of elderly care and elsewhere. The user needs and preferences (see section 2.4.) are a good starting point. It provides the very point of developing technology in the first place, rather than being a later moral constraint on how desirable goals are permitted to be pursued. Such later moral constraints are needed as well, since ends do not justify means. Rights and dignity of persons, and the equal status of everyone are not to be violated, and the four central principles of applied ethics (non-maleficence, beneficence, autonomy, justice, See Beauchamp and Childress, 2012) are to be respected. In some sense such constraints are however only a secondary, protective role that moral considerations take – the primary role is that of providing the aims to which technological means could be useful.

The ideal of autonomous good life has two elements: i) quality of life, and ii) the autonomous capacity to lead such a life. Humans are in principle capable of living an autonomous good life, but it has preconditions, such as available resources and capabilities of persons. The responsibility of others and of society is focused mostly on providing preconditions for such a life, whereas it is the responsibility of the individual and his/her close collaborators to do the actual living. The ability to be autonomous comes in degrees, and in a typical human life, autonomy develops gradually from childhood to adulthood and again starts to degrade in older age. For providing the preconditions, a very rough understanding of what people need is sufficient, whereas more detailed plans for life can be left for the individuals themselves.

Understandings of preconditions of good autonomous life can be found by looking at various things that are supported by state budgets as preconditions of the lives of citizens, or at criteria of "decent human life“ in legislation such as the minimum level of income, or from lists of human rights declarations: money, food, shelter, libraries, health care, social interaction, care, etc. They can also be found from various philosophically stylized lists such as the list of 10 most important human capabilities (Nussbaum, 2011), or 10 types of recognition what are vital human needs (need for respect, need for love, need for esteem; see Laitinen, Niemelä & Pirhonen, 2016).

Central moral constraints can be based on human dignity. It, too, has many aspects: it is both an inalienable status and a quality evinced by people who are dignified. Both are something to keep in mind when treating others, behaving oneself, and in distributing means for a living. These perspectives are illustrated in Figure 2, Nursing home residents' concept of dignity (Pleschberger, 2007), which nicely captures the three central aspects of dignity in relation to recognition.

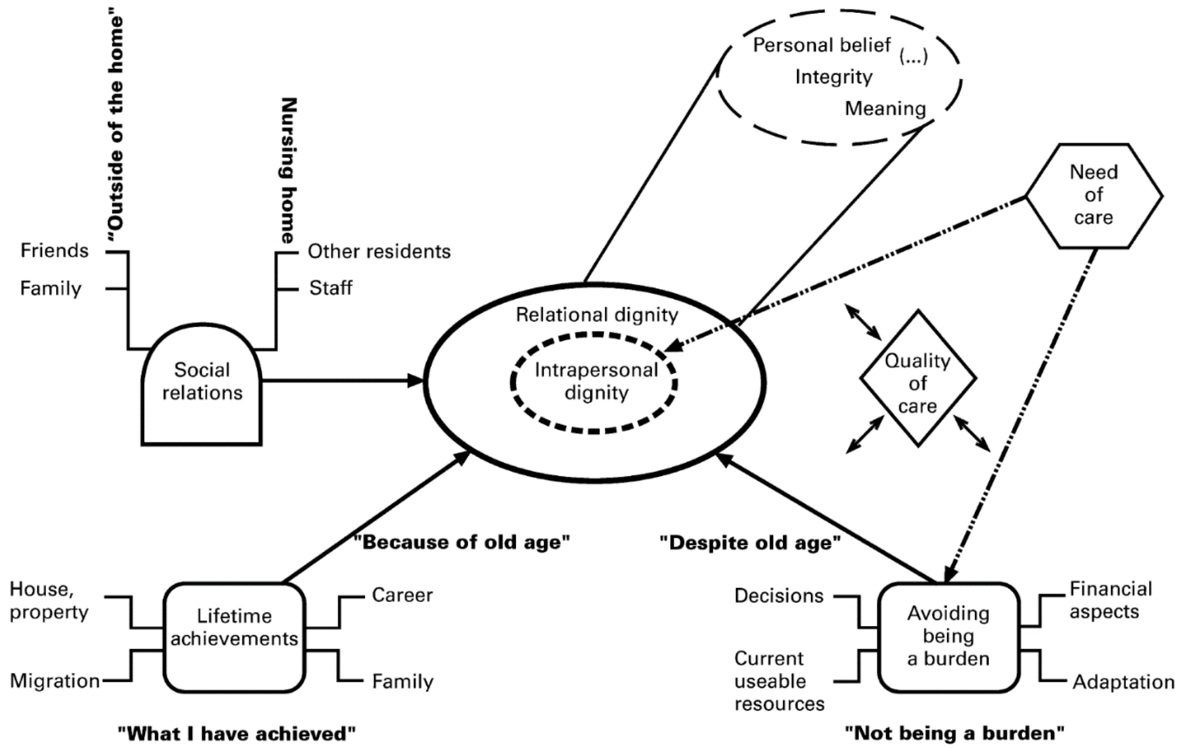

Figure 2. Nursing home residents' concept of dignity. (Pleschberger, 2007, p. 199).

Dignity is, in one sense, something that need not be deserved, but all are automatically entitled to. On the other hand, various lifetime achievements are the basis of differential esteem, so that "because of old age" one has more lifetime achievements, than in one's youth. And further, we are all dependent on the care of others, more so in infancy and old age, than in the prime of our lives, but we are dependent animals. These three aspects are reflected in universal respect, particularistic differential esteem, and in the care for the needy and in special relations such as friendship. By seeing to it that mutual respect, mutual esteem and mutual care prevail, ethical standing of humans, whether nursing home residents or not, are well taken care of.

5.1.3 Citizens' panel

Ethical deliberation is not a prerogative of presumed authorities, but the task of all. In this subsection we mention one practice that can be used in facilitating ethical deliberation: that of Citizens' panels.

Researches of the ROSE project organized a citizen panel together with the Institute of Bioethics in Tampere in winter 2017 to find out how citizens argue about care robots and justify their use or non-use in elderly care services. The 26 panelists were mostly 60–80 year-old citizens with no special care needs nor knowledge on robotics i.e. they are presumably among the first to meet robots when cared for in the future. Some of the participants had experience of care technology, others had almost none. The main target of the panel was to formulate a joint declaration on care robots and their legitimate use in elderly care in Finland. The panel had three sessions and the final result was the two-page declaration which all the panelists could agree on. The panel emphasized five important dimensions regarding the future usage of care robots. *Self-determination* entails that the usage of robots should primarily be based on individual's choice. People should be *informed and educated* on robotics-related matters before larger introduction of care robots in care services. Not only the medical and nursing professionals should be educated but also citizens. Matters of *responsibility* regarding care robots should be clear before the robots are used in care provision. *Justice and equity* should be the main priorities regarding the implementation of robots. Every citizen should be entitled to similar public services regardless of his/her own possibilities to purchase hi-tech equipment. In the end, *humanity* comes first and every person is entitled to human interaction. Robots may take care of some human needs, they cannot care about human beings.

5.2 Technological opportunities: Vision for 5-10 years

5.2.1 Supporting workforce in healthcare institutions

5-years:

Robots will support clinical workforce in well-defined tasks especially in hospital logistics (delivering supplies, waste, food, laundry) and administering medication. Semi-autonomous mobility aids such as mobile hospital beds become available for institutional environments. Critical issues for hospital logistics are cost, infrastructure (especially communication network availability), worker resistance, and product and support availability (close support desired). Also concrete measures and demonstration tools of system performance (e.g. safety, reliability) and cost effectiveness will be needed so that the benefits and limitations of the technology can be effectively communicated.

Telepresence (possibly robotic) and remote health will be used in settings including tele-psychiatry, tele-dermatology and tele-wellness promotion. Critical issues for telepresence and remote health are communication network quality, mobility of robots (for home settings), privacy and usability.

10-years:

Robots will support workforce in patient transfer (bed to chair) and patient mobility as well as dangerous activities in highly infectious disease care (e.g., ebola). Critical issues are similar to above (5 years). As autonomy increases, integration to workflows becomes crucial.

Telepresence robots will acquire semi-autonomous functions, allowing users to use higher-level commands such as navigation goals. Critical issues as above.

5.2.2 Rehabilitation and physical support

5-years:

Robot-assisted therapy will help people during upper and lower body function recovery. Such therapy will be personalized (e.g., tuned to the body type of the person) in order to motivate and offer the best possible treatment. Physical support will come in the form of sensory and motor prostheses that actively assist in arm function (e.g., reaching) and lower body function (e.g., walking). Combined, these exoskeletons will increase mobility and independence.

10-years:

Prostheses and exoskeletons will have increased sensory capabilities, connecting movement function with neural pathways.

5.2.3 Personal physical assistance

5-years:

Robotic mobility aids such as intelligent walking aids that can e.g. navigate or help to avoid collisions will be available for institutional environments. Critical issues for adoption include price, physical safety and reliability.

Single purpose domestic help robots (robotic machines) for purposes such as cleaning and personal hygiene will be available. Critical issues as above.

10-years:

Mobility aids will become available for more complex environments, including outdoors and homes.

Parcels will be delivered by autonomous systems. Critical issues include communication network, long-term mapping technology, reliability and security (including resilience to vandalism and crime).

General purpose physical support robots (e.g. robotic housekeepers) are not foreseen in next 10 yrs. due to excessive price and immaturity of technology, rather only application specific solutions will be available.

5.2.4 Personal cognitive and social assistance

5-years:

Robots will autonomously have short-term interactions in specific domains such as a health interview, using spoken language and following human social communication norms. Critical issues include technology (modeling social interaction, adaptation to social context, speech recognition in Finnish language), usability, regulation (for regulated activities such as health interview) and acceptance.

Digital-physical assistant robots will support communication between humans and provide information services (e.g. search on-line information, reminders), similar to current digital assistants (e.g. Siri). Compared to pure digital assistants, robots will provide additional sensor/perception capabilities but few if any physical capabilities. Critical issues similar to technological issues above, usability, and price.

10-years:

Robots will perform autonomously repeated interactions such as prescribed therapy in controlled environments. Critical issues as above plus technological ability to form long-term relationships.

Open dialogue will be available in limited domains for social/cognitive assistants.

6. Conclusion and Recommendations

6.1 Challenges in adoption of robots for services

There are many drivers for adopting robots for care services. One example is to increase the quality of life through better opportunities for independent living for the ageing population. Nevertheless, a primary driver for this adoption is likely to be cost savings in the public economy, at least in countries with public healthcare systems. For this reason, understanding the economic and social impacts of the adoption of a particular technology are vital for its adoption. Wide-spread adoption is not likely until there is evidence of beneficial long-term impacts.

Technological maturity of service robots is currently insufficient for many care applications. Technology gaps are seen in manipulation, long-term operation, social human-robot interaction, integration to other systems, and usability.

Ecosystem around robotics in care is immature. There is no credible, skilled national operator that could connect care technologies, related services and service users. The business ecosystem is still largely at the birth stage, and the wider innovation ecosystem is immature and essential stakeholders are missing.

User acceptance is crucial for adoption. At the moment, the acceptance of robots in care varies widely. Major factors include extent of personal experience and type of application. There is both a lack of knowledge as well as a lack of personal experience.

6.2. Research roadmap

There is need for new knowledge in several areas:

- The economic and social impacts of adoption of each technology need to be better understood. This calls for long-term pilots.
- Technologies that require further understanding include manipulation, long-term operation and autonomy, and social human-robot interaction.
- Usability of robots and intuitive human-robot interaction needs to be studied to bring robots to layman users.
- Integration of robot assistance to care environments and care systems.

6.3 Policy recommendations for Finland

There a many small scale pilots of robots. Wide-spread adoption requires understanding long-term impacts. This calls for collecting and compiling information from the pilots as well as coordination among them. Longer-term pilots will require greater public investment but such investment should be made for cases where there is strong evidence of major impacts from the smaller pilots.

Acceptance of robots in care can be addressed by communication. Public outreach actions should be tied to all pilots.

New ways to provide public services may require redefinition of quality of service standards. Current standards based on the number of personnel may not be applicable when the processes and means of providing services vary across different service providers.

The use of robots in care setting requires support from the infrastructure, for example in form of communication network and accessibility. Thus, it is important to consider these requirements when making long-term investments in the infrastructure. Moreover, standardization of at least some of the requirements may be beneficial by allowing better compatibility of products creating larger markets.

Finland appears to possess good opportunities to build a functioning innovation ecosystem around care robotics, as the well-established Finnish technological and welfare systems form a synergic platform for actors and stakeholders to co-operate, allowing both public and private institutions as well as developers and users to participate in planning of robotic services. In order to reach a cutting edge position in use and production of robotic systems in care services, a systematic and multidisciplinary research, innovation and education program is needed.

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