Robot Companions For Citizens: Roadmapping The Potential For Future Robots In Empowering Older People

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Abstract. The Future Emerging Technologies (FET) Flagship Candidate "Robot Companions for Citizens" (RCC) proposes a transformative initiative, addressing a cross-domain grand scientific and technological challenge, to develop a new class of machines and embodied information technologies, called *Robot Companions for Citizens* (RCCs) that can assist European society to achieve sustainable welfare. The central premise of RCC is that to solve many important problems in the real world one has to be physically instantiated and capable of action; information alone is not sufficient. An important theme is that this new generation of safe and human-friendly robots could assist in extending the active independent lives of older citizens and help compensate for the demographic shift in the age of EU citizens. In this paper we summarise some of the main conclusions of the Flagship pilot in relation to developing robot technologies that can empower older European citizens.

Keywords: robot companions, assistive technology, flagship, ageing, use cases, robot ethics, attitudes to technology, universal design

1 The Robot Companions for Citizens Flagship Proposal

In 2010, the European Commission's ICT Future Emerging Technologies (FET) Programme initiated a competition to select six pilot projects for consideration for funding as ten-year FET Flagship projects. "Robot Companions for Citizens" (RCC) was one of six candidates selected for a one year funding period beginning May 2011. Two of these six will be chosen to run as full flagships from 2013.

RCC proposes that a new class of embodied information technologies, called *Robot Companions for Citizens* (RCCs), could help European society to achieve sustainable welfare. An important theme is that this new generation of safe and human-friendly robots could assist in extending the active independent lives of older citizens and help compensate for the demographic shift in the age of EU citizens. As importantly, the project proposes that the development of future robots, and of their impacts upon society, should be structured according to European values and ethics; Europe should lead the way in ensuring that robotic technologies have positive societal impacts and are developed for the benefit of all.

In this paper we report on the activities of the RCC "Society" Community Working Group—forty-eight inter-disciplinary experts who collaborated to produce a roadmap for research into the societal aspects of the development of RCCs. The working group considered user requirements and perceptions of robots, ethical and legal issues surrounding the development and use of robots, and developed a human-centred design approach to the development of RCCs. Use-case scenarios envisaged potential applications for RCCs to support older citizens in maintaining or enhancing their lifestyle or their environment, and in assisting them with physical mobility and personal care.

The RCC flagship proposes advances in many areas of robotics from new materials and body designs, new power systems, new sensor and actuation systems, through to novel forms of robot control including improved self-awareness and understanding of human users. The planned technological advances envisaged by RCC are summarised in [1], along with proposals for taking these new integrated technologies from the laboratory and design studio, into community-based evaluation settings, and eventually into production with commercial partners. RCC is expected to have impacts in many spheres of human existence—private, social, economic, urban and physical. In this paper we focus specifically on the personal and social spheres and on the role of future robots as assistive technologies for individuals and families.

2 Robot Companions and the Welfare of Older Citizens

A critical welfare issue that has motivated the development of the RCC project is the dramatic demographic shift that is happening in the age of the European population. By 2060, 30 per cent of the population of Europe will be 65 years of age or over compared to 17 per cent in 2010 [2]. Moreover, the ratio of senior citizens (65 or over) to working citizens (20 to 64)—the old age dependency ratio—is expected to change from 28 per cent in 2010 to 58 per cent in 2060. Taking into account dependents under the age of 19, by 2060 there is expected to almost one dependent person (aged under 19 or 65 or over) to every one in work [2]. This is an unprecedented event—never before in human history have older citizens made up such a large proportion of the European populace. Along with a society with a greater number of older citizens we can also anticipate a society with a greater number of disabled citizens since the prevalence of disability increases with age. More specifically, whilst it is estimated that, worldwide, around 15 per cent of adults have some form of a disability, this rises to 46 per cent in those aged 60 and above [3]. We can thus say, with certainty, that this demographic shift will have enormous economic impacts (e.g., health, pensions, long-term care) as well as placing unprecedented demands on younger citizens for the care of their elders. On a more positive side, it is also important to recognise the aspirations and expectations of older citizens to lead active, fulfilling and independent lives and to continue to make a useful contribution to the wider society for as long as possible. Indeed, given good health and welfare, there is evidence that people are happier during this later phase of their life than at earlier stages of adulthood [4].

Whilst a coherent strategy for coping with the demographic shift will require much more than the development of enabling technologies, we see significant potential for using RCCs–advanced robots with much improved sensorimotor and cognitive capabilities—to address the welfare needs of the ageing society. Indeed, in introducing RCCs that can assist the welfare of older or disabled citizens we also expect to create technologies that are useful to all citizens. Rather than creating a single targeted technology, we therefore propose new forms of universal and adaptive robot technology that will be useful in the daily lives of European citizens.

The introduction of RCCs could potentially address the shortage of skilled labour in the caring professions that is expected to arise with the demographic shift. Suitably configured robots could assist carers to be more efficient, to cope with physically demanding tasks such as lifting, and allow them to focus more on the human-to-human aspects of their work. We are currently reaching a limit in the introduction of non-robotic ICT technologies in the home. No computer, however smart, can intervene to physically assist with many of the daily tasks that are performed by carers to help maintain the health and dignity of older citizens. At the moment, many older and disabled people rely on family, or on carers who are paid privately or by the state, to support them in these aspects of their daily lives. Wages for carers are low, and there are significant concerns about poor standards of care impacting on the human rights of those being cared for [5]. These problems will be exacerbated by the shifting ratio of older to younger people. The recruitment of foreign labour into the European caring professions does not solve this problem since evidence suggests that such immigrants will stay in Europe in old age contributing to the user need [6]. Where such immigrant carers are part of the black economy, there is also evidence of poor working conditions and, in some cases, abuse of worker human rights [6]. Improved medicine, by itself, it also not a solution to the problems created by the demographic shift. Indeed, medicine, by prolonging life, risks making some problems more acute, where peoples lives are extended but their ability to care for themselves remains compromised. Therefore we consider that the need to physically act in support of people's welfare, coupled with limited resources of European health care systems, implies potential benefits from more intelligent automation of assistance in the home and in environments for social care. To address this need is one of the primary goals of RCC.

In the context of deploying new types of robot to assist and empower older citizens it is useful to distinguish the needs of citizens in different phases of late life. In the so-called *third age*, people retain, broadly-speaking, both intellectual and physical function but are facing increasing challenges in *maintaining their environments* (e.g. difficulty completing household chores) through the gradual decline in these functions. Then in the final stage of life, the *fourth age*, people face additional challenges of acute or chronic illness, and increasing disability and dependency, that can be characterised as involving *difficulties in control of their bodies*. We propose that the development of RCCs can be focused towards both of these general categories of need.

Studies of ageing suggest that health, in the third age, can be promoted by (i) increased physical activity, (ii) good diet, (iii) greater social interaction, (iv) increase in perceived autonomy, and (v) improved sleep [8]. The challenge for RCC development is therefore to design robots that help to maintain or enhance one or more of these lifestyle-related areas without hindering others. As people age, it is important that they are assisted in making necessary psychosocial adjustments. For example, it may help to reduce the number of life goals, with performance of goal-based activities maintained through practice [9]. RCCs developed for the third age would therefore be required to support the process of healthy ageing by allowing maintenance of the physical and social activities that are important to the user and promoting feelings of control and empowerment.

The needs of citizens in the fourth age are determined by the extent of their physical and cognitive impairments, disease burden, and factors such as depression and withdrawal that may arise as a consequence of perceived loss of control and social isolation [7]. RCC technologies to improve life in the fourth age should, in addition to facilitating the lifestyle aspects of healthy ageing noted above, also specifically address problems of physical mobility and self-care (bathing, dressing, toileting, eating) that could be summarised as being about *maintaining and enhancing the self.*

The transition from third to fourth age can be triggered by negative health events but also psychological and social factors. McKee et al [10] conceptualises this period as the "Body Drop", where a sudden failing of the body in a healthy older person initiates or interacts with key psychosocial processes that precipitates a change in status from fit to frail. RCCs could therefore also have value if deployed to support people recovering from a negative health event, thus warding off the drop into the fourth age. A sudden deterioration, following a fall, major health event, or bereavement, is one of the mains reasons for people to enter forms of institutionalised care. More generally, Brownsell et al. [11] identified a total of 36 factors that can lead older people to require increased care or support, of which 58% can currently be ameliorated using assistive technology. These authors have also provided a prioritised list of the twelve factors most likely to lead to increased need for care in the UK. These included: deteriorating physical function, inability to care for self at home, mobility problems, need for assistance in personal care (hygiene, washing, dressing), difficulties in toileting, and general inability to cope with independent living—all factors that imply a need for physical assistance, and that could be addressed through the development of future RCCs.

3 State-of-the-art in Assistive Robots for Older Citizens

Widespread use of commercial robots for domestic use is currently limited to domains such as vacuuming, lawn-mowing, and entertainment (robot toys). The World Robot Report [12] estimates that over 2 million such units were sold worldwide in 2010 and projects increasing sales in the coming decade. Service robots sold for professional use are currently dominated by applications in defense and agriculture, with some units sold for applications in surgery and therapy.

The *Wakamaru* robot [13] introduced by Mitsubishi in 2005, was one of the first commercially available robots intended for home use. Wakamaru had a wheeled base with a humanoid upper-half including two arms, however, the robot's relatively high unit cost ($14,500) and limited physical and communicative ability led to poor sales and production was halted after three months. A variety of humanoid or semi-humanoid robots are now manufactured commercially but are sold primarily as research or entertainment platforms. One of the best known commercial platforms with a therapeutic use is the seal robot *Paro* [14] that has been positively evaluated as being a calming influence on patients with Alzheimer's disease.

Physically-assistive robots are beginning to enter the market, or are in trials, that can promote mobility and help with personal care [15]. These include wheelchairs with some autonomous steering capability, powered exo-skeletons that can restore legged walking, and various forms of robotic prosthetic limbs. Special-purpose robots are being evaluated to help in tasks such assisted sit-to-stand. A number of devices are already on the market for assisted feeding in which a spoon is mounted on a small robotic arm that can be controlled by a user who is unable to use their hands and arms [16, 17].

A second category of robots currently under evaluation are the socially-assistive robot platforms [18]. These robots are intended to promote the psychological well-being of users through social interaction, or provide assistance, by reminding or monitoring. Physical interaction with users is relatively limited in part due to safety concerns. A review by Broekens et al. [19] identified a range of studies investigating the potential value of such devices in the care of older people noting some positive qualitative evidence, but criticising the general lack of methodological rigour that made it difficult to rule out confounding factors.

The overall picture, then, is that general-purpose household assistive robots are some way off. However, there has been a steady advance in, and significant take-up of, robots that perform useful single functions. These tasks can be characterised as (i) requiring limited sensing and actuation capability, (ii) requiring limited communication with the user, (iii) involving relatively low autonomy particular when interacting with users. In parallel there has progress in developing physical-assistive devices and platforms that can socially interact successfully with older people, with some evidence of positive impact. Significant advances in robot technology will be required before home and assistive robots can progress to more complex tasks or to duties that involve more direct and self-controlled robot-human interaction, as is the case with many of the tasks involved in caring for older people. The RCC Flagship will therefore direct most of its efforts to developing new robotic technologies that can overcome these challenges.

4 Design Requirements for RCCs

Our analyses of potential uses for RCCs in empowering older people suggest that a significant advance is needed in robotic capabilities to finely manipulate objects, and to physically interact and communicate with users. Improvement in dextrous manipulation are essential for a range of tasks from tidying the home, preparing meals, helping with dressing and undressing, to many aspects of personal care. To physically interact with people in a safe manner is necessary if robots are to help with user mobility, personal care and hygiene, and with tasks such as eating and bathing. In order to do these tasks well, the robot will also need to understand the needs and intentions of users, predicting and anticipating their behaviour where possible. This implies a significant advance in robot communication skills—both verbal and non-verbal. RCCs will also need the cognitive capabilities to understand how they are perceived by human users, allowing them to perform socially and physically appropriate behaviours that people will find helpful. Since space in the home is generally limited, and since large robots are less energy-efficient and potentially more hazardous than smaller ones, we also foresee a need for small-footprint lightweight robot designs.

Our investigations have therefore identified a number of properties of RCCs that could be critical for enabling a range of societally-useful robot platforms. These are summarised in the following list which is proposed as an initial guide, from the societal perspective, as to where effort in the science and technology aspects of the RCC flagship should be directed. We focus here on functional specifications as the design and engineering of systems that implement this desired functionality is outside the scope of this report. We note that many of these requirements are beyond the capabilities of existing robot platforms.

Physical and sensorimotor requirements

- Safety
  - Good environmental awareness particularly for people and animals
  - Ability to monitor environment for human health risks (e.g. escaped gas)
  - Strong but compliant actuation
  - Lightweight materials, appropriate combination of hard and soft parts
  - High-levels of mechanical robustness, electrical safety etc.
  - Fast, reflexive, low-level safety loops and overrides
- Skilled manipulation

  - Good sensitivity for object properties
  - Fine control of end-manipulators
  - Variable stiffness and strength
  - Capacity for task-sharing with human users
- Robust locomotion
  - Sure-footed control of movement indoor and outdoors
  - Ability to carry loads
  - Quiet, energy-efficient, with ability to operate in darkness
- Appearance and physical characteristics
  - Non-threatening, task-appropriate, customisable
  - Lightweight and compact for easy storage and transport

Cognition and sentience

- User understanding
  - Linguistic and non-linguistic two-way communicative capacity
  - Ability to recognise and remember individuals and their life histories
  - Ability to monitor health status & anticipate human behaviour and needs
  - Sensitive to human norms and able to recognize social contexts
  - Ability to infer intent from informal or non-verbal instructions
  - Customisable interfaces
- Planning
  - Appropriate levels of autonomy
  - Capacity to learn from experience and to remember own history
  - Able to plan collaboratively with other RCCs and to interact with and control domestic appliances
  - Reconfigurable, adaptable
- Privacy and security
  - Robust data protection systems
  - Resistant to re-programming for inappropriate or illegal use

5 Human-centered Design of RCCs

The inclusion of potential user communities in the design process is critical to ensuring that RCCs make a useful contribution to European welfare. The RCC flagship will adopt a *human-centred design methodology* for the development of assistive robotic technologies which requires an iterative cycle of platform development beginning with approaches such as task-analysis and scenario-based planning. Although design with specific user groups in mind will be important for some RCCs a more general strategy of *universal* or *inclusive design* will be promoted, whereby RCCs are designed so as to be useable by anybody. Indeed, such a strategy can increase the potential market for RCCs whilst increasing their appeal to users in specific target communities. The physical appearance of RCCs will be important, as too will be factors such as physical size, material build, and 'life-like' appearance. Expertise in industrial design will be required to create attractive RCCs as will research in human-robot interaction to promote usability.

The human-centred design process should include all potential user groups as different groups will have different needs. For instance, RCCs aimed at people in the third age should support the process of healthy ageing (i.e., extending and enhancing this stage whilst maintaining perceptions of empowerment) whereas RCCs aimed at people in the fourth age should also compensate for failing abilities. Furthermore, different tasks may require different RCC characteristics; for example, users may want machine-like RCCs to assist in hygiene tasks to avoid social embarrassment, but more human-like RCCs for social engagement.

Forlizzi, et al. [22] evoke the principles of universal design and talk of the need for robots that are a good fit to the 'ecology of ageing'. Older people value identity, dignity, independence and have particular aesthetic needs. They have a wealth of personal meanings embedded in cherished artefacts and need to pursue personal growth, maintain social ties and experience pleasure. Understanding people in their ecology means knowing who would like assistance and who would not. Many older people will be put off by technologies that seem intrusive, complex, embarrassing or disruptive [23]. The approach of designing an assistive robot to fit a human ecological system demands new tools, methods and techniques that will extend current conceptions of human-centred design. For instance, designing for the delicate home ecology will requires ethnography, home observations, understanding the sense of place and togetherness [20], and subtle probes to get designers to appreciate the needs and opportunities for robot companions.

There is a need to move beyond current methods such as scenario-based design and requirements gathering. For instance, mixed methodologies can be used on a larger scale to determine what features potential users would like their RCCs to have. Surveys, interviews and focus groups can be used to find out what tasks users would like their RCCs to be able to perform and what features they would like an RCC to have. Experimental studies can then be used to find the type of characteristics that users prefer. For instance, a novel use of gaming technology could be used to explore the desired design characteristics of RCCs whereby users could design their own robot with a range of individually-tailored characteristics.

As with all technology there is a half-life of usefulness brought on by performance redundancy and wear and tear. It is the duty of all the designers for RCCs (science, engineering and aesthetic) to ensure that these devices do not become future landfill and that they are ecologically efficient in their use of materials and fabrication processes. Human-centered design methodology implies that there will be several generations and iterations of these devices so design and development will be an ongoing empirical affair leading to generations of technically redundant devices. Thought must go in, at the design stage, as to what will become of these; reuse of materials and total life management will be important issues and it may be likely that these devices are leased rather than sold, enabling the service provider to control their use and recycling.

6 Robot Behaviour and Personality

The appearance, character and personality of the RCC will have an emotional impact on those who are using and interacting with it. People should not be scared of, or intimidated by these devices. The prospect of an army of identical robots may be seen as dystopic, however if RCCs are variable according to function, taste and lifestyle (like our automobiles and clothes), but have the same basic mechanical components, they will have a broader appeal.

Furthermore, a degree of customizability of the devices is desirable to allow these to be genuinely inclusive tools for the modern lifestyle, this can cover all aspects of its character and personality from what it looks like to how it behaves. One approach may be to produce a relatively aesthetically-neutral device that is designed to be customized with 'skins' or 'clothes' and functional accessories and relevant behavior programming according to taste.

Research on human-robot interaction has raised the question of what social norms robots should know and act upon. People have a tendency to treat complex machines as social actors [24] and may therefore respond to robots socially, as they would in interactions with other people. Research shows, for example, that breakdowns arising in human-human communication, such as perspectives-taking and grounding, are replicated in human-robot interaction (see, e.g. [25]). Users also perceive personality in robot behaviour and appearance [26, 27]. If a robot has a compelling personality, people may be more willing to interact with it and establish a relationship [28, 29].

In designing a robot personality, there are many challenges to consider. For instance, a robot may change its personality according to the user it interacts with, however, there is also evidence that human users expect virtual characters to have a consistent personality [30]. Robot personality is conveyed in many ways. Emotions can be used to portray stereotype personalities such as friendly or grumpy, and the robot's embodiment (e.g. size, shape, color), its motion, and the manner in which it communicates (e.g., natural language) also contribute strongly [31]. Finally, the tasks a robot performs may also influence the way its personality is perceived [32].

The perception of personality and social behaviours are strongly intertwined. For instance, entertainment robots are usually programmed with engaging, if rather simple, social abilities, and service robots have been outfitted with social behaviours to smooth incidental interaction with humans (for instance, a hospital delivery robot that encounters humans in the corridor [33]). Therapeutic robots offer specific behaviours, such as a social response to touch, to assist in therapy (e.g. *Paro* as described by [14]). Recent research has also considered how we can sustain long-term human-robot personal relationships by embuing robots with emotional intelligence and appropriate social skills (e.g. [34]). The RCC flagship aims to extend this state of the art by exploring social behaviours that specifically contribute to older persons acceptance of robots in their daily lives to ensure effective, fun, comforting and safe support in the third and fourth age.

7 Perceptions and Acceptance of RCCs

Understanding how people perceive robots is a fundamental step in assessing how accepting people are likely to be of allowing RCCs into their homes, their lives and their society. Through understanding what people think and feel about future RCCs, and which particular beliefs influence acceptance of RCCs, the Flagship can create RCCs that meet people's wants as well as their needs. Furthermore, use of psychological interventions and theoretically informed communication strategies to target key perceptions can promote a balanced appraisal of the costs and benefits of RCCs in prospective users.

Research on perceptions and acceptance can be used to inform the communication strategy of RCC developers. Previous research has suggested that the developed technologies should likely be promoted as 'lifestyle accessories' as opposed to 'aids to ageing well'. Research suggests that most technologies used with ageing or older people are perceived negatively, due to transference of the negative attributes associated with old age to the technologies connected to old age. Indeed, being required to use technologies associated with old age may cause a person to see him/herself as old, and a self-identity of old person is not necessarily commensurate with sustaining the healthy ageing process.

There are some limitations in the current research on user needs. For example, we know little about the impact of technology as lifestyle facilitator within the early late life group: what are the young-old age groups developmental needs as they start retirement, what are the psychological, social, and physical tasks and goals within which they perceive the greatest potential for technology? Most research on user needs, in relation to assistive robots, has employed self-report measures of users' beliefs about new technologies. Given that self-reports rely on peoples' ability to accurately report their beliefs, and may be subject to social desirability effects, further research with unobtrusive (or 'implicit') measures of attitude would be valuable.

Moreover, our understanding of how technologies can assist best in supporting frail older people is hindered by the lack of research on older people as care-receivers. While a large amount of work provides a context for understanding the needs and perceptions of family carers, there is a corresponding dearth of good quality studies on older persons' experiences when receiving care. To what extent is technology perceived as an invasive or assistive force, and how does this perception differ between carer and care-receiver? The RCC flagship would therefore seek to promote research on these topics alongside the development and evaluation of future RCCs.

8 Ethical Issues

Ethics can sometimes appear to technologists as a costly, and unproductive obligation, however, we recognise that ultimately it liberates us from pursuing unproductive dead-ends, helps us to better identify and pursue socially-useful goals, and improves the overall quality and relevance of our work. Ethically-robust development of RCCs requires that scientific and technological work within the

Flagship project upholds the highest ethical standards, that robot ethics issues [37, 38] are resolved by adequate implementation of ethical analysis into technical design and functionality, and that the Flagship takes moral responsibility over its products especially for unintended effects.

A 21st century view of science recognises that it is not isolated from society and politics [35]. To be ethical a science and technology project on the scale of a Flagship requires engaging in a public dialogue that is broader than just user involvement, and that takes into account all sectors of society. The scientists and technologists will require humility and empathy to understand the concerns of lay people. Societal concerns about technology can be effectively addressed only through an *open science* approach [36] that takes seriously alternative viewpoints. Integrating ethics into the project requires that critical, sceptical and even dissenting voices are attended to at all stages. The project management must be prepared to change track if the results of these consultations reveal discomforts about the path being taken that cannot be satisfactorily addressed.

Like all technologies, robotics has the potential for beneficial use and for potential misuse (e.g. use as weapons), and it is essential that adequate safeguards are developed to avoid the latter [37, 38]. It is also vital that plans for the deployment of robots are carefully analysed to identify potential negative, unintended consequences. For instance, a home-help robot could potentially reduce the physical activity engaged in by an older citizen in a manner that is more detrimental than the boost to independence that it creates. Other issues include the need to guard against the reduction in human contact that might occur as a consequence of an increased use of robots [39, 40]. The question of the possible deception of the elderly has also been raised (e.g. [39, 41], although the natural anthropomorphism of people, and their tendency to exhibit a willing suspension of disbelief complicates the picture. The use of robots as sex aids also needs to considered from a societal perspective [42].

In the RCC Flagship we will consider ethical issues along two dimensions as illustrated in the figure below (adapted from [43]). The societal impact dimension (vertical) is concerned with the effects of RCCs on people and on European society, projected here along the dimension of time from the short-term to the very long-term. In the first 1-10 years we expect significant social and commercial impact of RCCs, in the longer-term—ten years and longer—we expect to see transformational impacts of RCCs on human-machine and human-human relationships. The ethics programme for RCC will involve studies of user needs and perceptions, robot ethics approaches, and science and technology studies of long-term impacts. Empirical and field studies of various kinds will also be required to address these issues.

Equally important is the dimension of research practice (horizontal axis in the Figure) and of ethical governance of the Flagship project. Here we consider the relationship of the RCC Consortium to the European public, during the course of the project, and in relation to the manner in which we conduct our research. We plan to be an exemplar large-scale publicly-funded R&D project by demonstrating that research can be pursued in the context of a meaningful

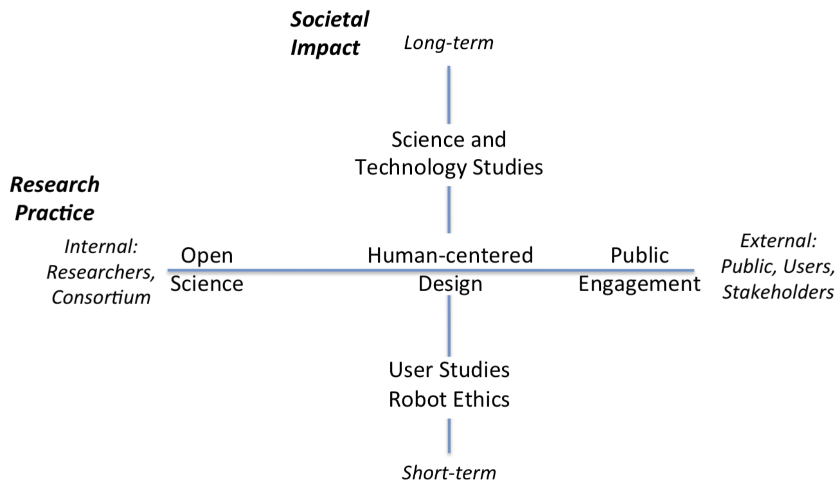

Fig. 1. The two dimensions of ethics in the proposed FET-F Robot Companions for Citizens—investigating societal impacts (vertical) and pursuing research practices that foster a meaningful exchange with the wider European society (horizontal).

dialogue with the wider community. All researchers in RCC will be trained in open science practices in order to implement this policy. In addition to practising research in the open, we will also proactively initiate and sustain a direct dialogue with society through an extensive programme of public engagement activity. We will, of course, address the groups who may be most directly impacted by RCCs—the prospective users, but we will also address non-users who may be impacted by the development of this technology.

9 Taking a Proactive Stance on Legal Issues

There are significant legal issues that need to be addressed if RCCs are to be deployed in European society including our personal and public spaces. These issues include the legal status and capacity of the RCC, liability in case of damage or injury, data privacy, standardisation and issues regarding intellectual property ownership in RCC-generated works. The RCC Flagship will take a proactive approach to ensure that these issues are carefully examined in advance of steps to commercial RCC platforms, and members of the consortium are already active in these areas such as the preparation of a robot law Green Paper [44].

When RCC's become active in our personal and social spaces, their acts will have legal impact. For an RCC to fulfil its function as a companion it may need to enter into valid legal transactions, such as purchase agreements. Therefore it is to be expected that some legal capacity will be required. On the other hand, if in the course of their activities material or personal damages occur, the question of who would be liable implies a range of potential candidates from computer programmers, manufacturers involved in the production of RCCs to the user of the RCC. At the same time, RCCs with some self-awareness cannot be treated simply as things. Sentience, autonomy and the possible ability to experience frustration, or even suffering, raise issues of legal categorisation. The question arises as to whether and how degrees of sentience, autonomy and capacity for feeling could be assessed as a basis for assigning legal standing of RCCs. Another issue that will have to be addressed is the RCC is its capacity for creating and inventing robot-generated works or patentable inventions. This raises fundamental questions with regard to the objects of intellectual property rights, and to the ownership of rights.

Whilst RCCs are unique in some respects it is also important to recognise that many of the potential legal issues surrounding robots are already addressed in existing legislation. For instance, regulations surrounding corporate entities, IT systems, motor vehicles, or even domestic animals could be relevant to evaluating the legal status of RCCs. Therefore the RCC Flagship will identify how and where RCCs fit into existing legislative frameworks and where such frameworks will need to be extended to take account of RCCs. By doing this the RCC Flagship will seek to develop appropriate legal instruments to both protect consumer interests (privacy, safety regulations) and to contribute to the innovation and acceptance of RCC technology in society by finding a balance between protection, security and innovation.

10 Conclusion

The demographic shift is an unprecedented event in the history of Europe. Fortunately, current generations have the opportunity to anticipate its arrival and to act—politically, socially, and through the development of new science and technology—to do what is needed to moderate its negative effects. The Robot Companions for Citizens FET Flagship pilot envisages a new generation of dextrous, socially-aware, and human-friendly robot technologies. As part of a wider effort to adjust to the changing shape of our society, we believe that the development of this new class of assistive systems can make an important contribution to the empowerment and well-being of all citizens, and particularly to current generations of working adults as they become old.

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