Implementing an ethical approach to big data analytics in assistive robotics for elderly with dementia.

Citation: Felzmann, H., Beyan, T., Ryan, M. and Beyan (2015) Implementing an ethical approach to big data analytics in assistive robotics for elderly with dementia. ETHICOMP2015, De Montfort University, Leicester, UK. September 7–9.

ABSTRACT

In this paper, we analyse the ethical relevance of emerging informational aspects in robotics for the area of care robotics. We identify specific informational characteristics of contemporary and emerging robots, especially the fact of their increasing informational connectedness. We then outline specific ethical considerations arising in the design process in the H2020 project MARIO which aims to develop a care robot for persons with mild to moderate dementia in home and residential care settings. Ethical considerations regarding specific functionalities of the proposed care robot are outlined.

Categories and Subject Descriptors

K.4.1 [Public Policy Issues]: Ethics; K.4.2 [Social Issues]: Assistive technologies for persons with disabilities

General Terms

Design, Human Factors.

Keywords

Care robotics, information ethics, privacy, value-sensitive design

INTRODUCTION

Big data analytics in the area of health care is currently considered to be one of the most promising innovative approaches to increasing knowledge of health factors and, ultimately, to improving the delivery of health care. Health care stakeholders now have unprecedented types and quantities of data at their fingertips. The area of care for the elderly is one of the areas where big data analytics might contribute substantial improvements; ICT solutions like assistive robotics and ambient assisted living (AAL) for the elderly hold the promise of supporting independent living for the elderly beyond the stage at which currently more intense forms of monitoring and care, often in quite restrictive residential settings, is considered necessary.

However, while big data has a huge potential to create significant value, it also contributes to qualitatively new concerns with regard to the use of personal information.

In this paper we will present considerations in addressing information related ethical issues in the development of a particular assistive care robot within the European H2020 project MARIO ("Managing active and healthy aging with use of caring service robots"). The project aims to develop an assistive care robot for persons with mild and early moderate dementia. These service robots will be used to support users in retaining their health and ability to perform activities of daily life, and increase their social connectedness and resilience, thereby mitigating the effects of dementia. The goal is to allow persons with dementia to stay living independently in the community for as long as possible.

CARE ROBOTICS: AN ETHICALLY SENSITIVE FIELD

Care robotics is a field of robotics that has been emerging over the last decade as a response to demographic developments in the developed world. Countries like Japan have pursued the use of robots in elderly care for a long time. Europe is now pursuing similar developments, with the European research agenda including care robotics for the elderly as a part of their strategies for aging, and the European Strategic Research Agenda for Robotics in Europe 2014-2020 (SPARC) identifying assisted living robots as part of the growing market of consumer robots [13]. Similarly, the UK Robotics and Autonomous Systems (RAS) strategy RAS 2020 includes reference to health and social care robotics for the elderly population [11].

Despite its strategic endorsement as promising area of technological innovation, there has been significant unease with the introduction of care robotics into elderly care settings. Most prominently, and frequently mentioned in strategic documents, concerns centre around the changes the introduction of robots bring to the nature of care, in particular the potential dehumanisation of care and the replacement of caring interpersonal relationships with machines. Most documents acknowledge that these concerns need to be addressed with sensitivity for care robotics to gain social acceptability.

Ethically speaking, these concerns are ultimately about the question whether core values of care can be realised when care robotics enters the picture, and if so, under what circumstances (). The nature of the relationship between robots and humans is at the centre of these concerns. In their influential review article Sharkey & Sharkey [12] have set out six core problems in relation to elderly care robotics: (1) the potential reduction of the amount of human contact the elderly person receives, as care is being delegated to the robot; (2) the potential increase in feelings of objectification and loss of control of the elderly person due to robot monitoring and standardised intervention into their activities of daily life without being part of a mutual relationship in which the relationship can be re-defined and re-negotiated; (3) a loss of privacy, due to continuous monitoring and recording in their daily life of their activities and expressions by the robot; (4) a loss of personal liberty due to restrictive interventions by the robot; (5) deception and infantilisation due to uses of robots that may foster the build-up of attitudes that are not appropriate to the robot's actual characteristics and capabilities (e.g. beliefs regarding the robot's emotional relationship to and care for the person) or may not do justice to their human dignity (e.g. through provision of interactive opportunities or physical features appropriate for small children rather than adults); (6) the question with regard to the circumstances in which elderly people should be allowed to control robots whose purpose may include monitoring, and behavioural interventions like reminding, activating, incentivising which for optimal effect would require functioning independently of the elderly person's mood and preferences.

What is evident from this list, as well as many other writings on the ethics of care robotics, is that while issues relating to the ethics of information are addressed and certainly implicitly present, they are significantly less prominent than the aspects of personal dignity and the nature of the relationship between robot and elderly person. The focus on the human-robot relationship is not surprising given that ethical care is generally described as an essentially interpersonal phenomenon. We do not intend to question the fundamental significance of realising ethical care, but what we aim to do in the following is to further foreground the informational aspect, especially in light of recent developments in the field of ICT that have transformed, and are continuing to transform, the informational functions of robots..

THE USE OF INFORMATION IN CARE ROBOTICS

In robot ethics, ethical issues relating to the use of information have been less strongly emphasised in the literature. However, as we argue here, the informational dimension is becoming increasingly more complex and significant, as robots in general, but especially most care robots have transformed from tools designed for highly specific, often physical tasks to multipurpose information hubs that are highly connected with their environment and have highly complex distributed information flows as essential characteristic of their functioning.

One obvious core concern with regard to the use of information is the issue of informational privacy. Privacy concerns are much discussed in the literature on all information technologies, and have been for some time. Their significance is evident also in the widespread awareness among laypersons of privacy as an important issue in the field of ICT. In order to appreciate the particular meaning of privacy concerns in the context of care robotics, it is essential to understand recent technological and functional developments for care robots and consider questions of privacy in the particular context of the robot's functioning in everyday life on the basis of its informational architecture. As Nissenbaum [8, 9] has elaborated in her influential contributions to the debate, privacy needs to be considered in relation to the specific contexts of use, where information practices and privacy expectations may differ significantly. In the following we will first outline the complexity of the informational architecture in current care robots and then discuss how these considerations manifest themselves in relation to specific care robot functionalities envisaged in the MARIO project.

Robots as information hubs

Alaiad and Zhou define privacy concerns as the stakeholders' lack of control over the collection and use of their personal information after they have adopted the system [1]. Despite the fact that robots are perceived as independent entities by their users, they generally communicate with many other systems. Many care robot functionalities may require storage of data and the comparison of data with other systems such as electronic health records, or they may repurpose the stored data to improve their intelligence. With new advances in pervasive computing and ambient assisted living environments, the sharing of personal data between robots and components of smart environments has already begun and will increasingly become more common and pervasive.

Robots as part of such an ecosystem will go significantly beyond their traditional role as stand-alone entities that facilitate specified parts of care, but instead become nodes of complex information sharing networks. Robots that are equipped with sensing and communication capabilities will interact with a wide range of sensors and distributed data sources. Core care robot functionalities, such as monitoring users to detect potential health risks, require communicating with wireless physiological sensors and accessing users' health records. Especially care robots with the purpose of facilitating independent living will increasingly interact with smart devices such as refrigerators, entertainment sets, heating systems, and become part of this pervasive informational environment, making IoT-aided robotics applications a tangible reality of our near future [5]. Companion robots similarly will increasingly use a variety of sensors and internet-based information for inferring context sensitive responses. Grieco et al. [5] highlight specifically two new advances in robot technology that will significantly change the way robots operate: IoT aided robotics applications and cloud robotics. These are increasingly redefining the robot's function and existence in distributed and pervasive environments.

IoT aided robotics applications are a digital ecosystem where humans, robots, and IoT nodes interact on a cooperative basis. The concept of the 'Internet of Things' (IoT) refers to the pervasive presence of a variety of things or objects – such as Radio-Frequency IDentification (RFID) tags, sensors, actuators, mobile phones, which are able to interact with each other and cooperate with their neighbours to reach common goals [4]. It is expected that sensor networks will become increasingly integral to the human environment, in which communication and information systems will be invisibly embedded [2]. That means that entities such as smart objects, sensors, servers, and network devices complement the robot, so that the robot and various IoT devices connect through a complex and heterogeneous network infrastructure. The robot interacts with the IoT, databases, and the internet and becomes a central node in this information network where all nodes are linked. The robot continuously interacts with the environment that is equipped with a wide range of intelligent devices and exploits this dense IoT network to fulfil tasks in a manner sensitive to changes in the environment [5].

In relation to challenges regarding the use of information, these fully decentralized and spatially distributed components raise unprecedented challenges for data security. The distributed IoT network is more vulnerable to attacks, especially due to frequently insufficient security features of smart devices. In this architecture attackers could hijack unsecured network devices, like sensors, routers and robots, converting them into bots to attack third parties or could target communication channels and extract data from the information flow [2]. Eavesdropping over the IoT network thus becomes possible, especially as attackers could target communication channels to extract information and data. This may lead to unauthorized access to massive amounts of private information. A particular threat could be denial of service attacks that overload networks. In some care contexts even temporary unavailability of the robot, in the case of such attacks, may cause harm to users or put them in danger. Moreover specific nodes of the IoT networks, such as the robots themselves, might be captured. If robots are hacked they might pose a danger to humans and their environment. These vulnerabilities may lead to serious user safety issues as well as privacy and security concerns for data stored on or transmitted through the system.

Cloud robotics is a new paradigm in robotics, where robots can take advantage of the Internet as a resource for massive parallel computation and real-time sharing of knowledge and big data sets [7]. The cloud robotic architecture leverages the combination of an ad-hoc cloud formed by machine-to-machine (M2M) communications among participating robots, and an infrastructure cloud where resources are dynamically allocated from a shared resource pool in the ubiquitous cloud, to support task offloading and information sharing in robotic applications [6]. Recently, cloud robotics applications have begun to explore novel approaches such as creating a web community by robots for robots to autonomously share descriptions of tasks they have learned [15]. For example, the DAvinCi project used cloud computing for service robots in large environments and parallelized some of the robotics algorithms as Map/Reduce tasks in Hadoop [3].

Although cloud robotics allows robots to benefit from the powerful computational, storage, and communications resources of cloud computing, it also brings challenges regarding security and privacy. De Oliveira [10] lists three relevant kinds of risks: (i) dependency on the connection and availability of the cloud computing resources, (ii) lack of control since a number of procedures are no more under the user's control, for example backups, where it is unclear to the user by whom is it performed and where the data is stored, (iii) vendor lock-in with the consequence that migration to other products and data portability may become impossible. In the healthcare setting these disadvantages may raise serious consequences related to the safety of user, when internet connections might be disrupted, the privacy of sensitive data, and the continuity of care if providers are changed. Threats have been considered particularly in relation to data privacy and security. Cloud computing means that all the computer hardware and software used by a Cloud client (a company, a public administration or an individual) is provided by another company (the Cloud service provider, CSP) and is accessed over the internet [10]. In cloud computing systems data is stored in multiple locations by various service providers [16]. This may lead to loss of control over data and consequently results in privacy concerns. Relevant threats include disclosure by cloud computing providers of personal or confidential data to third parties, including potentially clients' competitors for monetary reasons, or the replication and use of sensitive information for data mining purposes, or the use of personal data for a variety of purposes not authorised by the data subject or lacking a proper legal basis [10].

Robots as delegated agents of the user

In this densely connected ecosystem, robots are becoming increasingly autonomous decision makers. IoT devices and sensors continuously send information to the robot, and the robot is granted the autonomy to interact with these systems and make decisions about regulating the surrounding environment. The autonomy of robots has increased not just in relation to physical maneuverability, but also in relation to increasingly complex decision-making. Users of care robots, especially persons with dementia, will increasingly delegate many aspects of their decision making to the robot. Robots dynamically interact with complex systems and with increasing functional abilities will make a wide range of decisions and apply them on behalf of the user, potentially bypassing active input by the user entirely. This raises significant issues regarding the role and use of information that underlies such decision-making. Increasingly robots do not just impact on the the physical environment of their users or provide limited, task specific information, but control the informational environment for humans more comprehensively. In the literature, ethical and privacy considerations are mainly focused on the human–robot interaction and ethical characteristics of their relationship, however, the increasingly complex role of the robot in mediating the user's informational environment raises additional concerns.

A significant ethical consideration in this context is how the robot's autonomous actions will impact on the agency of the person who it serves. In addition, the autonomous decisions of the robot impact not only on the person they are serving, but also on the surrounding environment, including other systems and persons that are related to the user. While the robot may have significant information available on preferences and needs of the primary user, this might not be the case for other persons affected by robot actions. In this context, the wider question of what requirements an autonomous robot needs to fulfil to not impact unduly on other persons. The scope of robots' autonomous intervention also needs to be carefully defined, considering at what point and to what extent the robot should autonomously perform actions on behalf of the user, or make adjustments, presumably to improve their choices. In this context, it is essential to reflect on the significance of preserving agency and autonomy for the user. Actions that might be beneficial from a health point of view might not be beneficial from the agency or dignity point of view.

One rather mundane use case in this context would be the robots' creation of healthy shopping lists, making sure a choice of healthy food items are available to the user, for example through online ordering, and making suggestions on meals and snacks for the user on the basis of the items available. This is certainly in the service of health. However, it would need to be considered how important decisions on food are for the user, whether there are certain kinds of food that have a specific significance for the user, or whether retaining the autonomy of shopping is significant for the user's self-understanding.

Robots as providers of continuous representations of the user's life Care robots, as part of their functionality acquire comprehensive information about their owners, their immediate environment and lifestyle. The layout of the house, habits such as sleeping, exercising, third persons entering the house, appointments or communications online are continuously recorded. Even though it is an ethical convention not to store information regarding intimate situation such as bathing, the robot still needs to store substantial amounts of sensitive personal information about daily habits such as daily routine activities, eating habits, or social interactions, in order to ensure the desired functionality. Care robots also may interact with other IoT devices for grocery shopping, securing the house and measuring user's physiological parameters such as respiratory rate or blood pressure. They also may connect with medical records which provide additional personal information about the user. All this wider, distributed landscape of data is becoming integrated into the robot intelligence and provides more complex and comprehensive information than the robot itself could capture with its built-in monitoring devices.

In care settings that support users with dementia, robots are also loaded with data that may be used to address the memory impairments. Robots may store memories of significant people in the user's life, especially in the form of photos or videos, store information on their interests, such as the music they loved, the sports team they are following, or other hobbies and passions that they have been pursuing during their lives.

Moreover users need to be reminded about the people they know. To fulfill this requirement robots gather not only information about the user they are serving, but also about their families, neighbors, and friends. The names, faces, addresses and additional information about their relationship to the user is stored in the memory of the robot. With the robot's internet connection they can also be followed with social media, to supplement the stored information.

When robots collect all this information that is directly related to the private sphere of the lives of its users, it may accidentally or intentionally disclose such information to a third party. Syrdal, et al. studied robot users' feelings and concerns in case of an accidental information disclosure with the service robot PeopleBot [14]. The study showed that most of the participants felt uncomfortable about the robot sharing personal information in social settings without having control over such disclosures. Participants considered information about their personality and other psychological characteristics as sensitive. They also raised the concern about someone else's robot collecting information about them and using it. As robots become a part of smart living environments, they are further extending their observation capacity by communicating with other devices and by autonomously searching the internet, and they will collect much more in depth sensitive information not only on their owners, but also others who have connections to their owners and/or may be in the range of the robot's recording capacities. Neighbours living next door, an old friend from photos, family members will be entered into the robot's storage, frequently without their knowledge or agreement. Although all this information may serve a valuable purpose, the aggregation of significant amounts of such information is intrinsically problematic. Disclosure of such information, whether intentional or accidental, is only one issue. Due to its connected and searchable nature such information storage is significantly different in kind from photo albums, diaries, address books or collections of memorabilia, where other persons' information may similarly be stored without their knowledge, but would not be available for further use or data mining. These potential further uses of information and the preservation of privacy need to be taken into account in the design of the informational management of the robot.

MARIO FUNCTIONALITIES, ETHICAL CHALLENGES, AND POSSIBLE SOLUTIONS

The MARIO project aims to develop a multifunctional care robot that will support elderly persons with mild to early moderate dementia in maintaining their independence and social connectedness. It is targeted at both home and residential care settings. It will have a range of functionalities in the area of (i) health assessment and monitoring, (ii) reminders and instructions for activities of daily life, (iii) entertainment and hobbies, (iv) reminiscence and social contact. User preferences regarding these functionalities have been elicited from persons with dementia as well as formal and informal carers in three trial sites (in residential care settings in Galway, Ireland; in a geriatric unit at the IRCCS hospital Casa Sollievo della Sofferenza in San Giovanni Rotondo, Southern Italy; and in a community setting in Stockport, UK). However, the precise definitions of functionalities to be included has not been finalised at the time of writing, so the following considerations are still indicative. These different functionalities involve different challenges regarding the ethics of information and privacy management in particular. In the following the particular challenges and some suggested solutions for each of these categories will be discussed.

Health assessment and monitoring

Desiderata for the robot include the performance of monitoring of different health aspects, including potentially vital signs like blood pressure and some aspects of geriatric assessment. In addition, possibilities of monitoring the intake of medication and fluids, two major causes of adverse health impact in the geriatric setting, is also under discussion, although the precise technical implementation of those suggestions still needs to be determined. Such information will be transferred to the health records of the person with dementia, allowing for potentially more comprehensive and regular assessment than feasible otherwise, which would be especially desirable for persons living in the community as opposed to residential settings. One particular benefit of such regular information collection by the robot would be that health professionals assigned to the care of the user can be made aware of changes in a timely fashion, so that emerging risk factors indicating potential deterioration could be identified before adverse events take place. It is also intended to monitor and record when adverse events like falls occur. Proposals for robot functionalities in this context include the development of risk indices on the basis of such information.

However, the information processed in such assessment and monitoring activities is highly sensitive and raises data protection and privacy issues. Unlike the transfer and storage of medical data within protected internal networks for medical records in health organisations, in this case information will be transferred wirelessly and is likely to be stored in the cloud which might allow for potential data breaches at different points, especially if the robot is used in a home setting. In addition, monitoring for several of the functions will rely on video analysis and requires the processing and storing of significant amounts of rich behavioral information that is also highly identifiable. According to good data protection practice, it will need to be ensured that data recorded and especially data stored longer term is not excessive and that data processing and storage options either minimise data usage or have significant advantages over less data intensive alternatives. This principled reduction of data storage is also a core tenet of privacy by design. In particular, with a robot that will accompany the persons throughout the day, including times of intimate activities, it will be necessary to ensure privacy and make it possible that the robot will stop recording information, especially video footage, without need for active requests by the user.

In addition, the person with dementia will need to agree to any health assessment and monitoring function before the introduction of the robot, just like informed consent is usually required for any health intervention. This consent should not be an all-or-nothing consent, but a certain degree of flexibility should be possible, i.e. users should have the option of excluding at least certain functions. (In the context of the trials, this may need to be handled more rigidly due to the importance of maximising user data on all functionalities. However, gaining some experience with a consent process that is sensitive to the users' needs is desirable for the user trials.) The initial consent will need to be facilitated by a person with competence in working with persons with dementia, as particular challenges in relation to memory and confusion might arise in the information process. Informed consent is a challenging process under any circumstance, but even more so for persons who suffer from memory problems.

More generally, the initial consent should be embedded in an adaptable dynamic consent framework where different options, including the potential switching off of monitoring functions, should be made available to persons with dementia. It is desirable that a range of carefully designed modified settings would be made available depending on the user's level of capacity and health state. In the interest of users' autonomy and privacy, it is desirable for persons to have the option of switching off some of Mario's functions (or switching off the robot altogether), at least temporarily, unless doing so would bring significant risks. For example, users who have no history of falls or severe disorientation might have the option to switch off safety monitoring functions at the very least temporarily. In this context it is essential not to assume automatically that safety and health benefits are always the overriding values; the significance of a person's dignity and autonomy may mean that at times risks are taken to realise those other values.

Reminders and instructions for activities of daily life and safety

Intended functionalities for the robot include a variety of reminders and instructions for different activities that the elderly person might have problems remembering or executing correctly. This includes for example reminders for activities that should be performed regularly, for example to take medication, take fluids, engage in physical activity, or go to the toilet. It may include reminders of scheduled activities, visits or appointments, based on calendar information. It may also include reminders (based on local weather apps) regarding appropriate types of clothing when the person is leaving the house, or reminders (based on RFID signals) of relevant items to bring, like wallet, purse or keys, and identifying where those are located. It could include reminders of the date and time of day, especially when users wake up, as they are particularly prone to being disoriented at those time. For users who wake up at night and start wandering they should also be reminded to go back to bed and/or not to leave the house, when appropriate. Users might also be reminded to switch off the hob or adjust the heating if sensor data indicates that this is required, and shopping needs may be identified based on the fridge content and recorded food preferences.

Instructions for activities of daily life include, for example, instructions on the choice of clothes and/or the sequence of getting dressed, on the choice of cutlery, on how to find the way around in the house or institution, for example how to get to the toilet, the sitting room or common room, or back to one's bedroom (some of these could also be integrated with a social activity calendar). They may also be adapted to specific needs, depending on the particular challenges that an individual encounters in their environment.

Some reminders, in particular, can be set at fixed intervals, like in a calendar, without taking into account a person's actual activities. However, to be more sensitive to the activities of the user and any situation-specific need for help, some reminders and instructions will be implemented on the basis of actual user behaviour. Like the above case of health assessment and monitoring, this includes more extensive monitoring and recording of user behaviour, which raises privacy issues, especially urgently if intimate behaviour is involved. Accordingly, it would need to be assessed whether robot functionalities are likely to involve the use of sensitive information, and for those in particular it would need to be balanced carefully whether the additional benefit of flexibility and adaptation to user needs is sufficient to offset the risk of privacy infringements.

Instructions and reminders also come with the particular challenge not just of data privacy but also of social privacy, in the sense of reminders or instructions being audible or visible to third parties in the user's social environment. Reminders on activities that users and/or others generally expect adults to be able to perform themselves, and especially reminders for intimate activities, might be considered socially problematic by the user or their social environment and have the potential for significant embarrassment. This might be particularly significant for users who are experiencing uneven loss of abilities. They may be highly functioning in many domains and have a high level of self- awareness and social integration, but may have significant difficulties with particular activities which they would prefer to keep confidential from others. Accordingly, the design of the functionalities will need to take into account this potential for embarrassment and carefully design robot intervention so that less socially intrusive modalities for reminders and instructions are used when other persons are present to maximise privacy and dignity. This may be particularly significant for residential care settings where users may not have a single room to themselves, and accordingly robot interventions may be likely to be overheard/visible to others with regard to nearly all of the user's activities and not just restricted to defined social settings.

Entertainment and hobbies

Functionalities regarding entertainment and hobbies are particularly significant for persons with dementia, as they provide opportunities for activation, positive experiences and potentially also social integration. These are all relevant for a better experience of quality of life and constitute protective factors against the further decline of dementia symptoms. Envisaged MARIO functionalities include the provision of broadcast media access, games, and social media connectivity to relevant sports clubs or other information that the user is interested in or passionate about. It may also involve assisting users in searching for further information on matters of interest. Information on hobbies and interests, like previously discussed types of information stored through the robot, is similarly personal information where care should be taken to avoid breaches of privacy.

Facilitating continued engagement with subject matters that a person has been passionate about is particular valuable for persons with dementia who may have begun to withdraw from their ordinary activities and may be entering a vicious circle of mutually reinforcing withdrawal and further loss of functioning. For certain activities, one of the potential advantages of engaging with subject matters or games via the care robot can be that loss of functioning may make playing certain games with other persons difficult, while a robot might facilitate reminders and help to the person where needed, making possible the enjoyment of activities that may otherwise not be possible for the persons. For other activities, robot mediated activity might have a social dimension in that the robot might offer activities that are not just targeted to the primary user, but may involve peers. This might include singing, listening to music, watching movies, light exercise, or engaging in games. Given the importance of increasing social connectedness in persons with dementia, it is desirable to further explore the integration of a social dimension of activities provided by care robots.

The main information related concerns in using these functionalities correspond to previous considerations in relation to other functionalities. The robot might be collecting monitoring information of others that neither are aware of that fact nor have agreed to it, and such collection needs to be minimised. The robot also needs to be able to adapt its interactions with the user to the context, especially the distinction between individual and social settings. Interactions like reminders which might be appropriate in a one-on-one setting may be embarrassing or possibly convey too much personal information in social settings.

Reminiscence and social contact

Memory impairments are a core symptom of dementia. Reminiscence activities have been shown to be particularly beneficial for persons with dementia. These involve actively engaging persons with their memories of the past, for example persons, events and locations that were important to them. It allows them to reconnect and engage with important parts of their lives, counteracting confusion and a sense of loss that may be experienced in the engagement with the present where memory impairments often have their most significant impact. In contrast, persons with dementia can generally access long term memories much more easily than more recent events. Care robots can assist or facilitate reminiscence activities, either as an aid for interpersonal engagement with a carer or family member, or as an independent, fully robot-facilitated activity. In order to fulfil such a function, a significant amount of personal information needs to be stored in the robot, including basic information on family members and crucial events, photos, videos, and family stories. This raises a number of ethical issues around the use of information. First of all, it raises the issue whether consent is needed from others to store information that connects them to the person with dementia. For reasons of practicability but also the comparability to the use of social information and photos in other private and social contexts, such consent requirements should not be too onerous. The mere fact that photos of a person are stored should not be sufficient for demanding consent; however if extensive, sensitive or personally identifying information is being stored, seeking permission for this use would likely be appropriate. (What exactly a consent requirement entails could also be dependent on factors such as what technological possibilities of uses of such information are, whether these are implemented in any way in the robot, or what this person's sharing practices on social media are.) Seeking consent for such use of information might be raising privacy issues, insofar as it implicitly requires informing the person from whom consent is sought about the extent of the memory problem that the user is experiencing. How exactly consent should be sought and who should be in charge of addressing the issue are other open questions. It might be too onerous for the person with dementia to be responsible for the process; on the other hand it might be perceived as inappropriate or potentially patronising if another person is addressing the issue for the person with dementia. In addition, this raises the issue of data security and the potential for data breaches, which in this case affects not just the person with dementia, but also those persons whose information is being stored.

In addition to reminiscence activities, such personal information about other persons will also be used for a range of functions related to social connectedness. Functionalities in this area include the connection with social media and photo sharing services, the use of Skype or similar services, or the use of face recognition software to help the person with dementia identify persons upon meeting them. All these functions rely on storage of some information about other persons, but may also involve further collection of such information, such as social media contributions or current photos. Collection of such information by the robot needs to be designed to minimise stored data, for example through explicit requirements of selection of favourite photos, rather than wholesale storage of incoming information. One further consideration in relation to the use of social media is also that such use will also be analysed by social media providers, raising further privacy issues. Connection through a specific kind of robotic device might be identifiable; characteristics of dementia might also be inferred from contributions by those providers, like other psychological characteristics. This might not only have an impact on how advertising is targeted to the person on social media, but could potentially even have wider privacy implications if the person thus becomes identifiable as a person with dementia to the provider, or even additional parties if such information is being sought and sold on by providers or data brokers.

Finally, the use of stored information for social purposes like identification of a person on the basis of face recognition or the use of reminders on the personal connection to or shared experience with the person with dementia has the potential to be highly beneficial by improving social connectedness and avoiding awkward or hurtful moments of lack of recognition of a loved one or friend. However, depending on how reminders are presented to the person, they might be noticeable to the other person or even potentially socially disruptive. Care needs to be taken in the design process to implement such reminders in a discreet or socially acceptable manner.

CONCLUSION

As outlined in this paper, the informational challenges arising in care robotics are substantial and increasingly relevant. The potential of adapting and further refining care robot functionalities on the basis of massive amounts of complex connected information is considerable, but informational processes need to be adjusted on the basis of careful consideration of the ethical implications of such uses of information. Maximising privacy, both in the sense of data protection and social privacy, is a core concern. Allowing users and others affected by the collection and use of personal information sufficient transparency and control is a further challenge that needs to be met. Doing justice to these informational considerations is one important precondition for achieving ethical acceptability of care robots.

ACKNOWLEDGMENTS

The research leading to these results has received funding from the European Union Horizons 2020 – the Framework Programme for Research and Innovation (2014-2020) under grant agreement 643808 Project MARIO 'Managing active and healthy aging with use of caring service robots'.

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