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ORIGINAL PAPER

Granny and the robots: ethical issues in robot care for the elderly

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Abstract The growing proportion of elderly people in society, together with recent advances in robotics, makes the use of robots in elder care increasingly likely. We outline developments in the areas of robot applications for assisting the elderly and their carers, for monitoring their health and safety, and for providing them with companionship. Despite the possible benefits, we raise and discuss six main ethical concerns associated with: (1) the potential reduction in the amount of human contact; (2) an increase in the feelings of objectification and loss of control; (3) a loss of privacy; (4) a loss of personal liberty; (5) deception and infantilisation; (6) the circumstances in which elderly people should be allowed to control robots. We conclude by balancing the care benefits against the ethical costs. If introduced with foresight and careful guidelines, robots and robotic technology could improve the lives of the elderly, reducing their dependence, and creating more opportunities for social interaction

Keywords Elderly · Elder care · Robot · Assistive robotics · Surveillance · Companion · Guidelines

Introduction

Should we be concerned about the use of robots for elder care? It is often suggested that one way of coping with the increasing proportion of elderly people in our society is to use robotics and related technology. Indeed, there is a growing industry in developing robots for elder care. However, some ethical concerns are beginning to be expressed about these developments (e.g. Sparrow and Sparrow 2006; Sharkey and Sharkey 2010a; Sharkey 2008; Wallach and Allen 2009). There is concern, for instance, that using robots for elder care could result in increased social isolation, and could involve deception and loss of dignity. At the same time, researchers have provided some evidence of benefits for the elderly, particularly as a result of interacting with robot pets (Banks et al. 2008; Kanamori et al. 2002; Tamura et al. 2004).

In an effort to determine the likely effects of robots on the lives of senior citizens, we outline recent developments, and identify and discuss the ethical issues they raise. The three main ways in which robots might be used in elder care are: (1) to assist the elderly, and/or their carers in daily tasks; (2) to help monitor their behaviour and health; and (3) to provide companionship. It will become apparent that in each of these areas there are some reasons to fear that the introduction of robots could reduce the quality of life of elderly people. However, it will be argued that such effects are not inevitable, and robots and robotic technology could, if introduced appropriately, solve a number of the problems that elderly people face.

In our assessment of robots in elder care, we consider two different bases for the associated ethical concerns: human rights, and shared human values. We shall outline these in turn. An emphasis on human rights provides support for the assumption that the physical and the psychological welfare of the elderly is as important as the welfare of others. Amongst the fundamental human rights established in documents such as the Charter of the United Nations, and the Universal Declaration of Human Rights, those thought of as particularly relevant to the elderly include the right to a standard of living adequate for health

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and well-being; to private and family life; to freedom from torture and inhuman or degrading treatment; and to freedom from discrimination. If the human rights of the elderly are to be respected as much as the rights of other members of society, it is important to ensure that robots introduced into elder care do actually benefit the elderly themselves, and are not just designed to reduce the care burden on the rest of society. A human rights interpretation of our opening question, "Should we be concerned about the use of robots for elder care?" implies a consideration of the effect of robot care on the elderly themselves, as well as on their family and carers.

Human rights are inextricably related to morality, but they are more often discussed in terms of legislation, than practical ethics. A different way of grounding our deliberations is to consider the effect of robots in elderly care in terms of enduring human values, as discussed in the Value Sensitive Design approach (Friedman and Kahn 2003; Friedman et al. 2006).

Friedman and Kahn (2003) identify and discuss 12 human values that are implicated in technological design: human welfare; ownership and property; privacy; freedom from bias; universal usability; trust; autonomy; informed consent; accountability; identity; calmness; and environmental sustainability. In this paper, we attempt to identify the particular ethical concerns and human values implicated in robot care for the elderly. The most obviously relevant, and fundamental, human value that relates to robot care of the elderly is that of human welfare. It seems reasonable to assume that there is shared human concern about the physical and psychological welfare of the elderly. If robots were found to have a negative effect on their wellbeing, it would provide a clear reason to object to their use. Accordingly, we take concern about the possible impact of robots on the welfare of the elderly as our starting point.

In considering the ethical issues raised by various applications of robotics in elder care, our approach differs from that advocated in Value Sensitive Design, and other approaches that propose solutions and methods for the ethical design of technology. We are not trying to provide a complete account of how robots can be introduced without associated ethical problems. Our goal is a more preliminary one: to identify the probable risks, and possible advantages, of different forms of robot use. Doing so is a necessary first step towards the development of ethically satisfactory solutions. There is a pressing need to identify the likely effects of robot care before it becomes commonplace.

One of the main reasons to expect that robots will be used in the care of the elderly is that the number of elderly people in the population is beginning to overtake the numbers of young people able to do such caring. Japan has, for some time, had an eye to using machines to fill this care gap. Because of a low birth rate and long life expectancy, their population is aging rapidly, with 22% over the age of 65 in 2009, predicted to rise to 34% by 2035.[1] The worry is that there will not be enough young to look after the old and part of the Japanese government's health policy is to use robots for care. In March 2009, a Japanese ministry of trade and industry official, Motoki Korenaga, told Agence France-Presse that, "Japan wants to become an advanced country in the area of addressing the aging society with the use of robots."[2] He spoke of plans to prepare safety rules soon for robot nurses that are expected to serve elderly needs within the next 5 years.

Other countries may well wish to follow suit. Europe and the United States are facing similar aging population problems over a slightly longer time scale. In 2009, it was estimated that 16.2% of the population in the UK was aged 65 or older (CIA World Factbook). Spain and Italy are the oldest in Europe with 18.1, and 20.2% over 65 respectively (CIA World Factbook). These figures are increasing sharply. In the UK, the fastest growing age group is made up of those aged 80 years and over who in 2009 constituted 4.5% of the population. In the US, 12.8% are over the age of 65, expected to rise to around 20% by 2030. It seems likely that Europe and the US may want to follow the Japanese lead into robot care.

Whether or not robots are the best way to provide it, the frail elderly are clearly in need of care. Some lucky individuals manage to remain mentally and physically active until an advanced age, but there are many who need assistance in their daily lives and some who need complete care. The mobility problems of older people can mean that they need help to perform daily tasks in the home, and that they are not able to go out shopping, or to visit people. Some form of memory loss is inevitable with increasing age, and dementia is a prevalent problem. As well as lacking the physical ability to perform tasks, elderly people may need to be reminded of the need to perform various activities, or reminded of the locations for, and components of, those activities. Elderly people can be in danger of falling over, or becoming ill, or confused, or lost. They also need company, love and attention. In this paper, we provide an account of ways in which robots can be used in the care of the elderly under three headings: (1) Assistance; (2) Monitoring, and (3) Companionship. Our aim is to raise and discuss the ethical issues involved in each of these areas, and to consider their likely effects on the elderly themselves.

[1] http://www.reuters.com/news/globalcoverage/agingjapan.

[2] http://www.google.com/hostednews/afp/article/ALeqM5juSqhZryHpsVuY6mf93nr92g1qdA.

Assistive robots and elder care

A number of robots have been developed to assist with some of the daily tasks involved in eldercare. Such robots include the Japanese Secom "My Spoon" automatic feeding robot, and the Sanyo electric bathtub robot that automatically washes and rinses. Riken have developed the Riba robot (Robot for Interactive Body Assistance): it has a teddy bear face, and can pick up and carry humans from a bed to a wheelchair. It can recognise faces and voices and respond to spoken commands. In the US, Charlie Kemp at Georgia Tech, has developed an assistive robot, EI-E that can respond to many of the same commands, and perform the same tasks in a house that a guide dog is capable of. When coloured towels are tied to doors, and drawers, the robot can be instructed to open them, using a combination of verbal commands, and a laser pointer to indicate the target location. It can pick up quite a wider variety of objects from flat surfaces (Nguyen et al. 2008).

There are some interesting new developments arising from robotic technology that could improve the lives of the elderly. Cyberdene has developed the Hybrid Assistive Limb suit (HAL) which is currently available to rent in Japan. It detects nerve signals sent by a person attempting to move, and then is said to automatically move the muscle as the person expects. It can apparently multiply original strength by a factor of 2–10. There are also walking machines from Honda: 'Stride Management Assist', and their 'Walking Assist' device with body weight support system (New Scientist online, November 2008), although these are some way away from mass production. Wheelchairs for the elderly and the disabled are becoming increasingly sophisticated. For example, at MIT, Nicolas Roy and colleagues are working on an interface to a wheelchair that will enable it to take the user to a designated known location in an indoor environment, on vocal command (Doshi and Roy 2008).

These developments appear promising, but we cannot assume that all assistive robotic technology will be a good thing for the elderly people who encounter it. There are two main ethical concerns about the use of assistive robot care for the elderly and its effects on their welfare—first that it might reduce the amount of human contact that the elderly have, and second that if used insensitively, it could increase senior citizens' feeling of objectification and a lack of control over their lives. We consider each in turn.

One of the problems of aging is that it often results in a loss of social life and human contact. The worry is that the use of robots in elder care for tasks such as lifting, carrying, or even cleaning, might result in a reduction in the amount of human social contact that an elderly person experiences. Sparrow and Sparrow (2006), in their consideration of robots for the elderly concluded that if robots were used for tasks such as cleaning floors, this would remove a valuable opportunity for social interaction between a human cleaner, and the senior citizen, and as such should not be encouraged. Sharkey and Sharkey (2010b) make a related argument about "dull and dirty" tasks in the context of robot childcare—pointing out that these tasks often provide the opportunity for social interaction and bonding. It might be convenient to have an automated spoon feeding a frail elderly person, but this would remove an opportunity for detailed and caring human interaction.

Depriving senior citizens of social interaction with their fellow humans is an ethical issue that is not explicitly addressed by human rights legislation. Such a right is perhaps implied such as in Article 5 of the Universal Declaration of Human Rights, "*No one shall be subjected to torture or to cruel, inhuman or degrading treatment or punishment.*", or Article 9, "*No one shall be subjected to arbitrary arrest, detention or exile*".

Concern about the level of social contact experienced by the elderly follows from concern about their welfare. It might seem obvious that the elderly need contact with fellow human beings, and that their welfare would suffer in its absence. However, many elderly people still live quite isolated lives, and it seems worth considering some of the evidence that social interaction, or its absence, affects both the physical and psychological well-being of the elderly.

For instance, there is research that suggests that an extensive social network offers protection against some of the effects of aging: being single and living alone has been shown to be a risk factor for dementia (Fratiglioni et al. 2000). Saczynskil et al. (2006) in a study of 2,513 Japanese-American men, found that decreased social engagement from midlife to late life was associated with an increased risk of dementia. They speculate that social engagement reduces the risk of dementia by reducing stress, and consequently by reducing the hormones associated with stress (glucocorticoids and corticosteroids). Social and physical activity may also help because it "increase[s] a person's ability to tolerate brain pathology through enhanced synaptic activity and more efficient brain recovery and repair" (Saczynskil et al. 2006).

Wilson et al. (2007) studied the relationship between loneliness and the risk of Alzheimer's disease in 823 senior citizens in Chicago over a 5 year period. Those with a higher loneliness measure were more likely to develop Alzheimer's disease. Holtzman et al. (2004) found that frequent interaction in larger social networks was positively related to the maintenance of global cognitive function. They suggest that the effect might be the result of experiencing more novelty and variety, and from handling more complexity. Wang et al. (2002) similarly found evidence that a rich social network may decrease the risk of developing dementia, and concluded that both social

interaction and intellectual stimulation play an important role in reducing such risks.

There is further evidence of the beneficial effects of social contact on stress levels. Stress has been shown to exacerbate the effects of aging (Smith 2003), and recent research shows that social contact can reduce the level of stress a person experiences. Kikusui et al. (2006) provide a wide ranging review of the phenomena of *social buffering*, whereby highly social mammals show better recovery from distress when in the company of conspecifics. Social contact has a positive influence on both psychological and physiological aspects of social animals, and can be shown to reduce neuroendocrine stress responses in humans, rodents, birds, and non-human primates. It seems that social contact can have demonstrable biochemical effects on a person's body. A recent review (Heinrichs et al. 2009) concludes that the stress protective effects of social support may be the result of the oxytocin that is released in response to positive social interactions, and that oxytocin can have the effect of reducing stress. For instance, Heinrichs et al. (2003) found that when men were subjected to psychosocial stress (by means of the Trier Social Stress Test), their stress response was reduced by the presence of their best friend, and reduced further if oxytocin was also (intra-nasally) administered to them.

The research reviewed here shows both the beneficial effects of social contact, and attests to the increased stress and cognitive decline that can result from a loss of social interaction. Such evidence adds further weight to the concern that robots might result in the elderly having less human contact. It seems that reduced social interaction can have a measurable impact on the health and well-being of the elderly, and reinforces the idea that depriving them of such contact is unethical, and even a form of cruelty. Of course, what is not yet fully understood, and this is a question to be returned to in the section of robot companions, is the extent to which reduced or missing interaction with humans can be compensated for by interaction with robots.

There is another significant ethical concern to be raised in the context of assistive robotics, which concerns the problem of objectification of the elderly, and the way in which robots carry out elder care tasks. Who controls the robots? Are they are actually designed to help the elderly person, or to cut costs and reduce the workload of their carers? Often the focus is more on improving the lives of the caregivers, rather than ensuring that robotic assistance is provided in such a way as to improve the lives of the elderly themselves. Robots designed as replacement nurses or carers that carry out some of the same tasks of feeding, lifting etc., may make their charges feel like objects. Such robots could make elderly people feel that they had even less control over their lives than when they are dependent on human nursing care. Kitwood (1997) identifies "objectification" as one of the problems faced by those with dementia, and the same point surely applies to the frail elderly in general; "Objectification—treating a person as if they were a lump of dead matter: to be pushed, lifted, pumped or drained, without proper reference to the fact that they are sentient beings". If robots were to be used by human carers to lift and move elderly people insensitively, the well-being of those elderly people would be likely to be reduced.

Loss of human contact and increased objectification are examples of the negative impact that assistive robots could have on the lives of the elderly. At the same time, it is still possible that robotic technology could be utilised in such a way as to improve the lives of the elderly. Robots could be introduced with the aim of reducing senior citizens' dependence on the people that look after them. This could help, because it is unfortunately the case that human carers do not always treat the elderly with sufficient respect for their human rights, as discussed in the Joint Committee report on 'Human rights and elder care'(House of Lords, House of Commons Joint Committee on Human Rights 2006–2007). The following example is taken from the report, and illustrates the kinds of problem that can arise when elderly people are entirely dependent on busy nursing staff. It comes from an account given by a woman of her experience visiting her elderly husband in hospital:

"I went to visit my husband on the first day and he is a very private person, he doesn't like anything to embarrass him and when I went in he was almost in tears which is not my husband. He said 'please, please go and get a bottle I am nearly wetting myself'. I rushed out I got a bottle and I said to him 'Well why didn't you just ring the nurse', in my innocence. 'I have, for an hour and a half I've been asking for a bottle'. Well when I went out [and] told the nurse she said 'Oh don't worry we would have changed the sheets'. Now his dignity at that stage would have gone out of the window. There was no dignity." (p. 15)

Dignity, as referred to in this quotation, is a difficult concept to define, although intuitively quite easy to appreciate. It is related to the value of human welfare, since a person's psychological welfare is going to be affected by their physical needs failing to be met in this way. Dignity is also closely related to human rights (Schacter 1983). However, the point we wish to make here is that such situations could potentially be ameliorated through the use of robot technology developed with the aim of increasing the autonomy of the elderly, and decreasing their dependence on other people.

Robot technology that was under the control of an elderly person could empower them and increase their independence. For example, a robot wheelchair that could be summoned by an elderly person and instructed to take

them to the toilet could greatly improve their sense of control over their environment, and reduce the occurrence of distressing situations such as the one described in the example above. It might even turn out that, given the choice, some of the frail elderly might prefer robotic, as opposed to human, assistance for certain intimate tasks such as toileting, or bathing. The robotic technology could be developed more as a tool, rather than as an identifiable robot. It could even begin to function as an extension of the elderly person's body and mind as discussed by Clark and Chalmers (1998), and become "invisible in use" as discussed by Takayama (2010). The exoskeleton suit referred to above provides a good example—a frail elderly person's mobility and command of the environment would be considerably enhanced by such a suit. Empowering the elderly in this way and increasing their autonomy is likely to improve both their psychological and physical welfare (see Langer and Rodin 1976 for a classic example of the beneficial effects of greater control on the elderly, albeit not one enabled through robotics). As well as giving the elderly an increased sense of control and autonomy, robotic assistive technology could increase the social contact the elderly person experiences, by making it possible for them to get to and from social meeting places; again with likely improvements in their psychological welfare.

Assistive technology could improve the lives of the elderly, but it also implicates ethical concerns about autonomy. How much control, or autonomy, should an elderly person be allowed. To what extent should the answer to such a question depend on medical assessments of their mental capability? The right balance would need to be found between empowering an elderly person by making them mobile, and protecting them from the dangerous situations they might encounter as a result. If a senior were to request that a robot throws them off the balcony, should the robot carry out that command? Answering such questions with respect to the elderly is particularly complex because their cognitive, and physical, abilities cannot be assumed to remain at a particular level. It is likely, although not inevitable, that with increasing age a senior might become increasingly confused, and that their movements, particularly if facilitated by exoskeletons and the like, should perhaps be restricted in some way. Again, we are not offering a solution here, (although perhaps some form of driving test would be appropriate), but identifying the areas of concern for which solutions are needed. There is a delicate balance here to be struck between improving the psychological wellbeing of the elderly by granting them greater autonomy and independence, and protecting their physical welfare and keeping them from danger.

The issue of accountability should also be mentioned. There is obviously a need to ensure that robots used by the elderly are safe—and that if, for example, they are asked to pick a senior up, they do not miss the bed or chair, and drop them on the floor, or crash them into the wall. Furthermore, in a system in which a robot is responding to the commands of an elderly person, who or what should be held responsible and accountable if something goes wrong, resulting in injury or damage? If a senior citizen in an exoskeleton suit were to kick and injure a nurse, should they, or the suit be blamed?

Robots that monitor and supervise the elderly

A number of robots have been developed for monitoring the health and safety of elderly people. Pearl, developed at CMU (Pollack et al. 2002), is a "nursebot" that reminds seniors about routine activities (e.g. eating, drinking, taking medicine and using the bathroom/toilet), and that can guide them through their environment. RP-7 is a tele-operated robot that is used to facilitate doctor–patient interactions without the doctor leaving her office. It has been used at the Silverado Senior Living Apsen Park (Winner 2007). The uBot5 robot, developed by University of Massachusetts, Amherst (Deegan et al. 2007) has manipulators that enable it to perform a number of tasks such as picking up and moving objects around. It has been proposed as a means of doing house calls to check for signs of a stroke and could be used to monitor an elderly person for signs of a fall. It can also be used for social telepresence, since it can be remotely controlled by authorised users over the internet, allowing a virtual visit and two way conversation, with the visitor's face appearing on a video screen. The robot can also be remote controlled to perform tasks in the home. Mitsubishi Heavy Industries developed the Wakamura robot mainly as a companion (see next section), but it can also be used for monitoring the elderly, delivering messages and reminding about medicine.

Gecko Systems International Corp has predicted that its sales of eldercare personal robots will reach 8.3 billion dollars by 2014. They have developed the CareBot^{TM}, a personal robot equipped with multiple vital sign sensors, that can follow an elderly person in their home: home evaluation trials with the elderly began in November 2009. The CareBot is capable of verbal interaction, the delivery of medicine, video monitoring, two way interaction, and can provide verbal reminders at predetermined dates and times of the need for medical checks, or of other appointments. Gecko Systems claim that the CareBot provides a more cost-effective version of a "smart home", because the robot can follow the occupant from room to room, and reduce the need for sensors and wires throughout the house. They suggest that the CareBot could be used to allow a human carer some time off, by using it to monitor

the elderly person, and remind them to take their medicine. RoboSoft, a French robotics and automation manufacturer, recently introduced RoboLAB10, a home-assistance robot designed to assist in home care of the elderly. Details as yet are sketchy, but it apparently comes in two versions—one designed to supply physical assistance to elderly patients who have difficulty moving themselves or doing physical tasks around the house. The other is designed to assist those with cognitive difficulties due to Alzheimer's disease or other disorders.

In Osaka, Japan, Matsushita Electrics runs "Sincere Kourien", an elderly retirement home with 106 beds, and used it as a test bed for robot teddy bears that monitor patients' response times to spoken questions (Guardian online, 21st February 2002 http://news.bbc.co.uk/1/hi/sci/tech/1829021.stm). The bears record how long the residents spend performing various tasks, and can relay conclusions to staff, or alert them to unexpected changes. They form part of the monitoring network that exists throughout the building, and for instance alerts staff when residents leave their beds. Their use in the Sincere Kourien home illustrates a likely direction for monitoring robots, as a robotic component is integrated into a network of fixed sensors more typical of "smart" homes. Smart homes are also under development in the UK (e.g. Orpwood et al. 2008) but do not yet have robot components.

There are various reasons for expecting an expansion in this area of the robotics market. Robotic surveillance devices have already been developed for warfare, for policing and for home security (Sharkey 2009) and these could easily be adapted for monitoring the elderly. A robot that traverses the house, and relays information picked up by its sensors, is something that is well within the current technological limits.

We can get an idea of the future potential of monitoring robots with the Remote Presence robots (RP-6 and RP-7) made by the Californian company, Intouch Health (see http://www.intouchhealth.com/5Parkview-ICU-IHI-JCAHO.pdf). The RP-7 Robot is a 5 ft 5 inch robot that uses two way cameras, microphones and wireless technology including a joystick for control and a high speed internet connection to stream information. These have been piloted in a number of hospitals in Europe, Canada and the United States. Doctors can visit patients by remote controlling the robot to their bedside—the doctor's face appears on a monitor representing the robots head. They have even been used as a remote presence at a range of 5,400 miles by a surgeon in the US to guide an operation in Argentina.

Although such robots are currently prohibitively expensive (the RP-7 costs around $80,000) prices will fall and cheaper versions will appear. A monitoring robot could increase the safety of an elderly person in their own home, and make it possible for medical staff to virtually visit the elderly person and provide health checks. The elder person's family could also to check that they were taking their medicine, feeding themselves and so on. A remote controlled robot could reduce the loneliness of an elderly person if it were used as an interface for virtual visits by family and friends.

On the downside, we see three major concerns about the application of robots for monitoring. First, it is likely that the use of robots to monitor elderly people would result in a reduction in human contact and companionship. We have already discussed how using assistive robots could mean reducing contact with care workers. If a monitoring robot were used to make virtual visits to elderly parents, fewer real visits might take place. Although virtual family visits might alleviate loneliness to a certain extent, as suggested above, they would not be an adequate substitute for a living relative sharing your physical space and giving you a hug. If you could use a remote controlled robot to virtually visit your elderly mother, you might well be less likely to get in the car and go over to see her. Such virtual visits might alleviate a family's, and society's guilt about the elderly: providing reassuring evidence that they were still alive, and on their feet.

Our second concern is that there is a risk that monitoring could infringe on the right to privacy. The privacy of people in general should be respected (see Article 12 of the Universal Declaration of Human Rights, "*No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks*" and there seems little reason to make an exception for the old. Privacy can be expressed both as a right, but also as a generally recognised human value; it has certainly been discussed before in terms of computers, the internet and surveillance in general (e.g. Nissenbaum 1998; Tavani and Moor 2001).

An elderly person might not like to find that an operator could remote control a robot to peer round their apartment before they are dressed, or when they are taking a bath. They might prefer the robot to have to do the equivalent of knocking on the door and waiting to be invited in. The issue becomes more complex if an elderly person's mental state deteriorates further and they become confused. A person with Alzheimer's would probably forget that the robot was monitoring them, and could perform acts or say things thinking that they are in the privacy of their own home. Moreover, who should have access to the information, and how long it should be kept for? With the massive memory hard drives available today, it would be possible to record the entire remainder of an elderly person's life, but this is not something that they would necessarily consent to if they were able to. Their children, or family could

be asked for consent, but should they be allowed to sign away the senior's right to privacy?

Finally, there is a worry that loss of freedom could result from the use of robots to restrict the activities of the elderly. Such loss of freedom is related to the issue of autonomy raised in the preceding section. If robots are to be used to help elderly people to live safely in their own homes for longer, there is likely to be a need for them to function as autonomous supervisors. A simple extension would be to allow home customisation so that the robot can recognise danger signs, such as the cooker being left on, or the bath overflowing. A robot could make a first pass at warning a senior to stop doing or engaging in a potentially dangerous activity. But there are ethical problems here. If a robot can predict a dangerous situation, it could be programmed to autonomously take steps to prevent it, e.g. turning the cooker off, or even restraining the elderly person (gently) from carrying out a potentially dangerous action such as climbing up on a chair to get something from a cupboard. However, restraining a person to avoid harm could be a slippery slope towards authoritarian robotics.

A similar issue could arise with smart homes if sensors were used to detect that the elderly person is attempting to leave their room, for example, and to lock the door, or call the staff. Future developments are likely to create similar problems. For example, Lopes et al. (2009) have developed a method that allows tracking of people in a range of environments and lighting conditions without the use of sensor beacons. It might be possible in the future for a robot to follow a senior outside and alert carers of their location or encourage and guide them back into the home. The ethical danger here is that this could turn into the equivalent of imprisonment in the home without trial.

It is not difficult to construct consequentialist, or utilitarian scenarios where some robot action seems advisable. For example, if an elderly person was about to walk into the road onto heavy oncoming traffic and a robot could stop them, should it not do so? The problem here is in trusting the robot's classification and sensing systems to determine what is a dangerous activity. As an extreme case, imagine an elder having high calorie foods taken from her because the robot was preventing her from becoming harmfully obese. How would the law view a carer using a remote controlled robot to restrain an elder or take objects of potential harm from her, or him? Are the safety and health gains great enough to justify the resulting restriction of the individual's liberty? There are many discussions to be had over the costs and benefits of robot constraint and where to draw the line. As with many of the ethical concerns discussed in this paper, similar issues have been ethically debated in other contexts, (cf Wallach and Allen 2009), but it seems important to identify their particular manifestation in the context of robotics in eldercare before such applications have become commonplace.

There clearly needs to be a balance between improving the lives of the elderly by enabling them to live in their own homes for longer whilst protecting their individual rights, and their physical and psychological welfare. On the positive side, some of the concerns expressed here could be alleviated by the employment of a carefully customised system. A good model is provided, outside of robotics, by Orpwood et al. (2008) who report the development of a smart home for a particular man with dementia. Detailed records of his behaviour were taken, together with extensive consultation with his daughter, and care workers. Considerable effort was made to develop systems that increased his safety, but that did not remove control from him entirely. For instance, the cooker or taps would be turned off automatically if left on for some time, but he could override this. A system was developed that helped with his disorientation and confusion at night—when he left the bed at night, the light in the toilet was turned on, and a voice prompted him to visit the toilet. Similarly, if he went near the door of the apartment at night, the recorded voice of his daughter was played, encouraging him to go back to bed. If he ignored this, and left the apartment, then care staff in the building were alerted. The smart home development was shown to increase his urinary continence, and to improve his sleeping pattern.

Although the smart home solution did not involve robots, it provides a good example of the detailed consultation and customisation needed to produce a good working solution for an individual. It also provides an illustration of the achievement of an apparently successful balance between protecting this elderly person's physical health, whilst still preserving his freedom and control over his life. Similar sensitive customisation of monitoring robots, using a value sensitive design approach, may well turn out to be the best way of garnering the advantages afforded by robots, without reducing the quality of life of the elderly (see Forlizzi et al. 2004 for a related approach).

Robots as companions for the elderly

It is sometimes suggested that robots could provide companionship for the elderly. Indeed, an elderly person might be more likely to tolerate, or even enjoy, the presence of a monitoring robot if it also had some ability to be a companion. For instance, the Gecko CareBot referred to in the previous section is described as "a new kind of companion that always stays close to them enabling friends and family to care from afar". There is also a growing number of robot toys, some of which have been have been mooted as possible companions for the elderly. Such toys have the

advantage of being relatively more affordable than some of the more elaborate robots we have considered so far. We describe four such examples, before turning a cautious eye on research that claims to show the beneficial effects of robot companions, and moving to a consideration of the ethical implications of robot companions in general.

Paro, a fur covered robotic seal, was specifically designed for therapeutic uses with the elderly. Developed by AIST, it responds to petting by moving its tail and opening and closing its eyes. It reacts to sounds and can learn to respond to its name. It makes seal-like sounds, and is active in the day, preferring to "sleep" at night. It can detect light and dark by means of a light sensor, and recognise when it is being held, stroked, or hit, by means of posture and tactile sensors.

Sony's AIBO robotic dog, developed as an "entertainment robot", has also been used in robot companions research. It has a metallic dog-like form, and can walk, or chase a ball. It has sensors that can detect distance, acceleration, sound, vibration and pressure. It can express six "emotions" (happiness, anger, fear, sadness, surprise and dislike), by means of its tail, body movements, and the colour and shape of its eyes. Later versions could recognise voice commands, and the robot exhibits slightly different behaviour depending on the interactions it has experienced.

NeCoRo (OMRON) is a robotic cat covered in synthetic fur. Its behaviour depends on the history of its interactions and it can 'learn' to recognise its name. Stroking and hugging it elicits positive responses while treating it roughly elicits angry behaviour. Like Paro, it has internal rhythms that lead it to sleep, or seek to be cuddled. And finally, My Real Baby (iRobot) is described as an "interactive emotionally responsive doll". It can make different expressions, blink, and suck its thumb or bottle. It changes its expressed emotion depending on how it is treated—so that when fed and rocked for instance, it behaves as though it were sleepy. When unfed, it gets hungry and cries. It also makes a number of random sounds and words, which become more like sentences the longer it is played with.

There are other robots that have also been touted as possible companions for the elderly (see Wilks 2010 for interesting discussions of digital companions in general). Toy robots that could entertain the elderly include: Pleo, ifbot, and Primo Puel. Pleo is a robotic dinosaur with many sensors, which responds with different behaviours depending on its treatment. The ifbot was developed by Business Design Laboratory Co. for elderly people and can converse with them by means of a large number of stored interaction patterns. Primo Puel is an interactive doll that talks, giggles, and asks for cuddles. It was originally designed as a stand in for a boyfriend for young single women, but proved unexpectedly popular with elderly women in Japan.

Various studies have looked at the effect on the elderly of interacting with such robot companions, and claim to have found evidence that the elderly can benefit from them. The positive effects that are found are often said to be similar to those obtained from animal assisted therapy in which visits from a pet animal to residents of long term care facilities are found to reduce loneliness (Banks and Banks 2002, 2005). For instance, Kanamori et al. (2002) showed various improvements in elderly persons who interacted regularly with a Sony AIBO robotic dog—their loneliness scores were reduced, and their Quality of Life assessment scores improved. Banks et al. (2008) even found that elderly people in long term care facilities benefited as much from interacting with an AIBO robotic dog as from interacting with a real dog; both resulting in reductions in their reported levels of loneliness. Elderly dementia patients have also shown positive outcomes, including increased communication, as a result of sessions with an AIBO (Tamura et al. 2004). An interesting possibility that could be explored in future research is that some of the benefits that result from playing with, or "nurturing" robot pets are a consequence of increased levels of oxytocin, which as discussed earlier, appears to reduce stress.

These outcomes sound promising, but there is a need for caution in their interpretation because they depend on what the interactions are being compared to. The results reported by Kanamori et al. (2002) showed improvements in well being over time between initial and later sessions. Banks et al. (2008) showed that beneficial effects were obtained for those interacting with either the real or the robotic dog, as compared to their control group who received no such opportunities for interaction. However, such improvements could have been found because the alternative was so dire and unstimulating. Someone in solitary confinement might benefit from being given a robot companion, but they would benefit far more if they were offered a friendly social environment. It is not clear that the same relative improvements would be found if the comparison were to a control group that received some other form of intervention. If the comparison group received some other individual attention, such as a visit by someone who massaged their neck and shoulders, or who sat holding their hand and chatting, the benefits of the robot dog might not be so apparent. It is also important to see that any benefits are maintained over time, because a robot that was interesting to interact with initially may rapidly lose its appeal. A Reuters article (21st September 2007) reported that director of a Japanese care home had said that residents "liked the ifbot for about a month before they lost interest". The robot had spent most of the past 2 years languishing alone in a

corner, and the director of the facility commented, "stuffed animals are more popular".

As well as raising doubts about the reported benefits of interacting with robot pets, we can identify several ethical issues involved in the use of robot companions. First among these, as we have discussed in the other areas of robot care, is that their introduction could lead to a reduction in the amount of human contact that the elderly person experiences. At present, robots are far from being real companions. They can interact with people, and even show simulated emotions, but their conversational ability is still extremely limited. They cannot form adequate replacements for human love and attention. Unfortunately this does not mean that they will not be used as such: the Gecko CareBot is already being advertised as "a new kind of companion". There is a risk that despite its limitations, the provision of a robot companion could be used as a justification for leaving the senior citizen on their own for longer. It could be used to alleviate the family's guilt about doing so—"Don't worry about Granny, she's got the robot to talk to".

Then there are the issues of deception and infantilisation of the elderly. Sparrow (2002) and Sparrow and Sparrow (2006) argue that any beneficial effects of robot pets or companions are a consequence of deceiving the elderly person into thinking that the robot pet is something with which they could have a relationship, and are adamant that this should not be encouraged. Turkle et al. (2006a) expressed similar disquiet: "the fact that our parents, grandparents and our children might say 'I love you' to a robot who will say 'I love you' in return, does not feel completely comfortable; it raises questions about the kind of authenticity we require of our technology" (Turkle et al. 2006a, p. 360). Wallach and Allen (2009), in a discussion of the ability of robots to detect basic human social gestures, and respond with human-like social cues, suggest that, "From a puritanical perspective, all such techniques are arguably forms of deception" (Wallach and Allen, p. 44). Sparrow argued that the relationships of seniors with robot pets, "are predicated on mistaking, at a conscious or unconscious level, the robot for a real animal. For an individual to benefit significantly from ownership of a robot pet they must systematically delude themselves regarding the real nature of their relation with the animal. It requires sentimentality of a morally deplorable sort. Indulging in such sentimentality violates a (weak) duty that we have to ourselves to apprehend the world accurately. The design and manufacture of these robots is unethical in so far as it presupposes or encourages this", (Sparrow 2002).

Related to deception is the concern that encouraging elderly people to interact with robot toys has the effect of infantilising them. Similar points have been made in the context of doll therapy for dementia patients. Positive results have been obtained where dolls are introduced to elderly clients to act as a focus for reminiscence and conversation (Cayton 2006). For example, the "Someone to Care For" doll is made especially for the elderly, and the manufacturers claim that "These beautiful dolls offer comfort, care and happiness to senior citizens, especially people living with Alzheimer's disease". However, critics such as Cayton (2006) suggest that doll therapy is predicated on the idea that those with dementia are going through a second childhood, and that this notion is dispiriting and encourages a rigid authoritarian, deficit-based approach to care. Kitwood (1997) describes a malignant way of caring for those with dementia that leads to disempowerment, disparagement and infantilisation. The same could be said of the use of robot toys—which in some cases such as My Real Baby, are dolls with the addition of sensors and movement capabilities.

Despite these worries, we suggest that it is still possible to envisage ways in which robot companions, or robot pets in particular, might improve the lives of the elderly. Their introduction does not necessarily need to lead to a reduction in human contact. It is possible that robot pets could act as social facilitators, and lead to increased interactions between their elderly owners and other people. Robot toys can give the elderly person something to talk about, and to show, and other people something to talk to them about. For instance, when Wada and Shibata (2006) videoed interactions between a Paro robot seal and a group of elderly care home residents, they found evidence that the social interactions between the residents themselves increased, at the same time that physiological indicators showed reduced stress levels. It seems that Paro even encouraged positive communication, and resulted in a reduction of the "backbiting" that had previously characterised some of their interactions. One 75 year old female resident greatly increased her interaction with fellow residents. A friend of hers commented that she had been taciturn before Paro's arrival, but that now she was more cheerful and talkative.

A robot that facilitates conversation may function as an attractor for visitors. It gives a focus of attention for chat. Children may want to play with the robot and have fun with granddad's big toy. Kanamori et al. (2002) report the case of an 84-year-old man with cerebral apoplexy sequelae. He talked much more to his children after the introduction of an AIBO robot dog. It gave both him and them a focussed object to talk about. Thus benefits could be obtained from robot pets that are due to the robots stimulating increased interaction with other people; benefits that have nothing to do with deceiving the elderly person.

In addition, on further consideration the argument can be made that the issue of robot companions and deception

is not as straightforward as previous claims suggest (Sparrow 2002; Sparrow and Sparrow 2006; Wallach and Allen 2009). As discussed by Sharkey and Sharkey (2006), humans in general are all too ready to anthropomorphise machines, and other objects, and to imagine that they are capable of more than is actually the case. Zizek (2002) the psychoanalyst describes the way in which people can chose to act as though something were not real, "I know very well that this is just an inanimate object, but none the less I act as if I believe that this is a living being". There may well be elements of a "willing suspension of disbelief" (Coleridge 1817) when the elderly interact with robot pets.

It is quite possible that elderly people might enjoy, and benefit, from interacting with a robot pet without thinking that it is actually sentient. It is likely that their views about such artefacts are unclear—and that they will be seen neither as being sentient, nor as objects, but as falling "betwixt and between" known categories as discussed by Turkle et al. (2006a, b). Related questions have been investigated by Peter Kahn and his associates, albeit in the context of children and adults rather than the elderly. Kahn et al. (2006) looked at preschool children's reasoning about a Sony AIBO pet in comparison to a stuffed toy dog. Their results suggest that there was some confusion and inconsistency in the children's beliefs about the robot dog. The children's answers to questions about the robot dog and the stuffed dog were similar, but their behaviour was found to differ. They were more likely to mistreat the stuffed dog, and to animate it, than the robot dog, and they made more attempts to engage in reciprocal interaction with the AIBO. In a further study, (Melson et al. 2010, in press) children's interactions with and views of a living and a robot dog were compared. Again, although their views of the two differed (they saw the live dog as more likely than the robot to have physical essences, mental states, sociality and moral standing), most of the children still interacted with the AIBO as if it were a real dog. Kahn et al. (2006) suggest that a new technological genre of autonomous, adaptive, personified and embodied artefacts is emerging that the English language is not well-equipped to handle. They believe that there may be need for a new ontological category beyond the traditional distinction between animate and inanimate.

More psychological research is needed to provide a clearer picture of the beliefs that the elderly hold about robots they encounter, and of the effect of those beliefs. Elderly people might derive pleasure from acting as if the robot could understand them, whilst remaining aware of its mechanical nature. It is also possible that the elderly might still obtain benefits from interacting with a robot, even if efforts are made to ensure that they are made aware of its machine-like nature. For example, Turkle et al. (2006b) found that children who interacted with the MIT robots Cog and Kismet continued to see them "not only as "sort of alive" but as capable of being friends and companions" even when the researchers spent some time showing them how they worked and emphasising their underlying machinery. There are also likely to be considerable individual differences here, depending on factors such as for example, elderly people's knowledge and experience of technology, and their beliefs about and attitudes to mechanical devices. Turkle et al. (2006a) found that seniors interacting with robots showed considerable variations in their attitudes and behaviour towards them: for instance, some wanted to know how they worked in a mechanical sense, whereas others were content to interact with them 'as they presented themselves', with no interest in their underlying mechanism. It is quite likely that elderly people might vary in their level of interest in interacting with robot pets, and in the benefits that they obtained from such interactions.

Essentially, our suggestion here is that to claim that robot companions are unethical because their effectiveness depends on deception (Sparrow 2002; Sparrow and Sparrow 2006), oversimplifies the issue. The whole question of deception, and the possibility of the willing collusion of the elderly person themselves, is a complex one, and it is not clear that the benefits of robot companions depend on deceiving elderly people about their true nature. It is also not necessarily the case that interacting with robot pets means infantilising the elderly. Arguably, interacting with robots is more socially acceptable than playing with dolls, and robot toys are more likely to be viewed as "cool gadgets". This view is supported by Turkle et al. (2006a) who reported that elderly people were prepared to interact with robots: "Seniors felt social 'permission' with the robots presented as a highly valued and 'grown up' activity. "(Turkle et al. 2006a, p. 354). It seems that, if used with care, robot pets or companions could add extra interest to an elderly person's life, and might even improve their social life.

Conclusions

Our answer to the question posed at the outset of this paper, "should we be concerned about the use of robots for elder care?" is 'yes'. In each of the preceding three sections, we have identified ethical concerns. However, we have also found reasons to think that robots could make a positive contribution. It is not the use of robots in elder care per se that should concern us, but the ways in which they are used.

Several possible positive contributions that robots and robotic technology could make to the physical and the mental welfare of the elderly were highlighted. Assistive

robots and robotic technology could help to overcome problems of mobility, and reduce elderly people's dependence on busy, and sometimes inattentive, care staff. The use of remote controlled robots to monitor, and virtually visit elderly people could enable the elderly to live independently for longer. Robots could remind them what medicines to take, and watch out for health problems and safety risks. Companion robots could enrich the social lives of elderly people, by giving them an interesting gadget to talk to other people about. Social interaction could also be facilitated by monitoring robots that enabled virtual visits from friends and family.

At the same time, in the course of this paper we have identified a number of ethical issues of which developers and users need to be aware. If measures are not taken to guard against these concerns, there is a danger that robot use in elder care could lead to a dystopian environment. The quality of life of the elderly should always be put ahead of convenience to the system of care.

We have identified six major issues that need to be considered before deploying robot technology fully in eldercare: (1) Opportunities for human social contact could be reduced, and elderly people could be more neglected by society and their families than before. Robots could provide an excuse for such neglect, if others mistakenly chose to believe that the seniors' physical and emotional needs were being taken care of by machines; (2) The insensitive use of robots developed for the convenience of carers, and the consequent increase in elderly people's feelings of objectification, and loss of control. This could occur if, for instance, robots were used to lift or move people around, without consulting them; (3) Loss of privacy, and (4) The restriction of personal liberty that could result from the use of robots in elder care. The extent to which robots should be allowed to restrict the behaviours of humans is a difficult question, with implications beyond the care of the elderly; (5) The deception and infantilisation of elderly people that might result from encouraging them to interact with robots as if they were companions, (although as discussed, the possible willing collusion of the elderly with such deception makes this issue a complex one); and finally (6) If robots were placed under the control of elderly people, there is the issue of responsibility if things were to go wrong. But this opens up other important issues such as the extent to which the wishes of the elderly person should be followed, and the relationship between the amount of control given to the elderly person, and their state of mind.

Clearly issues such as privacy, safety, and autonomy are not unique to robotics for elder care and have been raised and discussed elsewhere—and there is an increasing interest in the notion of machine ethics in general (Allen et al. 2006). The contribution of the present paper lies in identifying and bringing together the various ethical issues for specific consideration in the context of robots in elder care. This is a pressing issue, for the indications are that robots will be regularly used in this domain. There has been some previous work in this area which has raised a small subset of similar ethical concerns, (Sparrow 2002; Sparrow and Sparrow 2006), and some which has focused on the development of eldercare robots that have some ability to ethically reason about what actions they should take (Anderson et al. 2006; Anderson and Anderson 2008).

Robots and robotic technology require a new perspective on many ethical issues, because of their embodiment, and their often life-like appearance. Their physical embodiment means that they can be used to perform tasks in the world to a greater extent than purely computational devices. For instance, robots, unlike computers, can follow a person around; as technology develops they are likely to be able to follow someone wherever they go. Similarly, as developments such as the Riba robot demonstrate, robots can be used to physically interact with people—for example, lifting them and moving them around. Their often personable appearance may lead them to be welcomed in the home and other locations, where for instance a surveillance camera would not be accepted. Finally, that personable, or animal-like appearance, can encourage and mislead people into thinking that robots are capable of more social understanding than is actually the case. Their appearance and behaviour can lead people to think that they could form adequate replacements for human companionship and interaction. Identifying the various consequences of such embodiment is an important contribution of this paper.

Identifying the ethical concerns associated with robots in elder care is a necessary first step in ensuring that their introduction will not result in a reduction in the welfare of the seniors exposed to them. Having identified these concerns, what should the next step be? A blanket ban would mean missing out on the many potential advantages that could be gained from the use of robots in eldercare. A particularly useful step would be to develop guidelines, and eventually legal restrictions, on their use.

Since the effect of robots on the lives of the elderly depends on the ways in which they are deployed, the development of guidelines about their use in care homes, and in their own homes, could help to guard against their misuse. At present, apart from fundamental human rights legislation, there is little protection for elderly people against the potential downsides of robot care. In particular, there are no obvious restrictions on the amount of time that elderly people could be left in the care of robots, nor on the amount of human contact that they should experience. Like children, the very old and infirm can be seen as being in need of special protection. As discussed elsewhere (Sharkey and Sharkey 2010b), children could possibly be

afforded some protection from extensive robot care by the legislation pertaining to neglect, but there is no such legislation for the elderly.

The lack of protection for the human rights of the elderly is often acknowledged. For instance, a recent report on human rights for the elderly (Older people and human rights, March 2009) points out that there is no binding international human rights treaty that specifically protects the rights of older people. Legal protection for elderly people relies on human rights legislation, but this report argues that 'There is a lack of enforceable economic, social and cultural rights in the UK, with the Human Rights Act focusing largely on civil and political rights. This omission has major implications for older people, who face a range of economic, social and cultural issues.' There are some international treaties that relate to the elderly. In 1991, the UN produced the "UN principles for older persons", but although this represents progress it is a declaration rather than binding international law. While such progress on the human rights of the elderly is encouraging, as yet there has been little discussion about the use of robots in eldercare.

Guidelines, and ideally legislation, about the uses of robots in the care of the elderly could limit the use to which robots were put. For example, guidelines could be drawn up about the amount of time that a person could be left alone with a robot without human company. There could be a requirement that any robot physically interacting with, or moving a person must first ask their permission. Further development of guidelines to guard against the likely problems of robot care would need to be based on careful evaluation of the effect of different forms of robot care on older people.

Ethical concerns about robots in eldercare could also be mitigated by means of detailed consultation with elderly people, with the aim of ensuring that robots introduced into elder care do actually result in improvements in the lives of the elderly. It is likely that there will be considerable individual differences in the attitudes of older people towards robots, (although these might be susceptible to change if they experienced some beneficial effect). Seniors are likely to differ in the extent to which they might be prepared to interact with a robot, and in their preferences. For instance, some older people might prefer the increased autonomy afforded by robotic technology that allowed them to feed themselves, whilst others might rather retain the opportunities to interact with human beings over such basic caring tasks. Sensitive customisation is likely to be needed in order to ensure a positive effect on the quality of life of the elderly.

Another approach would be to encourage robot developers to take a value sensitive design approach—building in protection against the ethical concerns raised here in the robots themselves. For example, a monitoring robot could have to always request permission before it started any form of monitoring of an elderly person, and it could be required to explicitly indicate when monitoring was taking place. Perhaps a companion robot could also keep track of the amount of interaction its elderly companion has had with other humans; it could take steps to increase the level of interaction when the level was very low. Maybe it could alert human carers that its charge was being neglected, or it could display a set of further behaviours designed to attract more interaction from other humans in the vicinity. But these are only preliminary suggestions; their further development is beyond the remit of the present paper.

In this paper, we have highlighted and discussed six ethical concerns associated with the incorporation of robots into eldercare. These concerns are related both to human rights, and to shared human values. At the same time, we have also identified benefits that could result from the careful incorporation of robots in elder care. It is argued that identifying both the risks, and the possible benefits, of elder care is a necessary precursor to the development of ethical solutions. In addition, we briefly considered ways of ensuring that the elderly experience the benefits, and not the downsides of robot care. The methods we suggest are (a) the development of guidelines, and ideally legislation, about their use, (b) basing these guidelines on carefully controlled studies and consultation with the elderly, and encouraging the development of customised solutions, and (c) value sensitive design of the robots in the first place.

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