Kenneth Kernaghan

The rights and wrongs of robotics: Ethics and robots in public organizations

Abstract: Some electronics experts believe that robots, like present-day computers, will be commonplace. A diverse assortment of robots, with varying purposes, capacities, forms, and sizes, is emerging with significant implications for the policy, service and regulatory responsibilities of government. This paper explores three public policy fields – aging, health care and defence – where the use of robotics is already substantial or where it is projected to grow substantially and where significant ethical issues exist or are anticipated. Applying ethical theories to the use of robotics is difficult. In the near-term, the focus should be on the ethical standards and behaviour of those designing, manufacturing, programming and operating robots. Several key topics in contemporary public sector ethics, including personal moral responsibility, privacy and accountability, are central to the emerging field of robot ethics. This suggests developing an ethics regime for robotics and examining the need for laws and regulations governing its use.

Sommaire : Certains experts en électronique pensent que les robots, tout comme les ordinateurs d'aujourd'hui, seront bientôt chose courante. Tout un assortiment de robots aux objectifs, capacités, formes et tailles variées, est en train de voir le jour, avec des répercussions considérables sur les responsabilités du gouvernement en matière de politiques, de services et de réglementation. Cet article examine trois domaines de politique publique – le vieillissement, les soins de santé et la défense – dans lesquels l'utilisation de la robotique est déjà considérable, ou prévue de s'accroître énormément et où d'importantes questions d'éthique existent ou sont anticipées. L'application des théories éthiques à l'utilisation de la robotique est un défi de taille. L'attention à court terme porte sur les normes d'éthique et le comportement des personnes qui interviennent dans la conception, la fabrication, la programmation et le fonctionnement des robots. Plusieurs sujets clés liés à l'éthique dans le secteur public contemporain, notamment la responsabilité morale personnelle, le respect de la vie privée et l'imputabilité, sont essentiels au domaine émergent de l'éthique de la robotique. Cela laisse entendre qu'il est souhaitable de développer un régime d'éthique pour la robotique et d'examiner le besoin d'avoir des lois et des règlements qui en gouvernent l'utilisation.

Robots have become a significant presence in industrialized states. They have moved in many respects from the realm of science fiction into the

Kenneth Kernaghan is professor emeritus of political science and management, Brock University, St. Catharines, Ontario.

CANADIAN PUBLIC ADMINISTRATION / ADMINISTRATION PUBLIQUE DU CANADA
VOLUME 57, NO. 4 (DECEMBER/DÉCEMBRE 2014), PP. 485–506

real world. Some electronics experts, including Bill Gates, predict that within a few decades robots will be as ubiquitous as computers are now (Gates 2007: 58; Siciliano and Khatib 2008: 1; Abney 2012: 41–4; Scheutz 2012: 205; Robotics VO 2013: 2). A substantial measure of intellectual, technical and financial resources are being devoted to developing and using robotics. During the past decade, attention has shifted from the longstanding focus on industrial robotics to much greater emphasis on service robotics. The editors of the 1600-page *Springer Handbook of Robotics* note that "the new generation of robots is expected to safely and dependably co-habitat with humans in homes, workplaces, and communities, providing support in services, entertainment, education, healthcare, manufacturing, and assistance" (Siciliano and Khatib 2008: 2).

While the near-term impact of the rise of robotics should not be overstated, it is time for public servants to begin thinking about this new challenge and, in some policy fields, positioning their organizations to manage it

Advances in robot technology, like those in computer technology, have substantial social, legal and ethical ramifications. This article focuses primarily on ethical issues associated with the current and anticipated use of robotics, with particular attention to the public sector. The article aims to sensitize public servants to the challenges posed by advances in robotics, to illustrate consequent ethical ramifications for public organizations and to argue for early attention to fostering ethical behaviour in the use of robots, including through codes of ethics.

While the near-term impact of the rise of robotics should not be overstated, it is time for public servants to begin thinking about this new challenge and, in some policy fields, positioning their organizations to manage it. The nature and extent of the impact will vary from one policy field to another. For example, robotics applications in departments of the *environment* include such activities as cleaning up contamination, exploring volcanoes, collecting data on global warming, and even monitoring great white sharks off the coast of California. Municipal water and sewage departments are using digital closed circuit television robots and other robotics technologies that move through difficult-to-inspect water mains and sewer pipes to pinpoint defects for priority repair. Police authorities use robots for such purposes as defusing bombs and reconnoitering potentially unsafe areas (as with the robot used in the 2013 search for the Boston Marathon bombing suspects).

A later section of this article examines three policy fields – aging, health care and defence – where robotics use is already substantial or where it is projected to grow considerably in the near future and where significant ethical issues exist or are anticipated. Among the issues are these: Is it ethical for governments to encourage the replacement of human caregivers for the elderly with robots? How much risk to non-combatants is acceptable in the use of unmanned aerial robots? Who is responsible if mistakes are made in the use of medical robotics? Responsibility for robotics use is a recurring theme in this article because governments will be tasked with determining who is responsible when robotics goes wrong – the designer, the manufacturer, the operator or the user? This is an imminent as well as a long-term challenge for public servants. Indeed, problems have already arisen from the use of robotics in caregiving, surgery and warfare.

it is important to distinguish between robots already in effective operation, those likely to be available in the near future, those on the distant horizon, those that are not only far-off but also far-fetched, and those that are unduly expensive

Public servants struggling to cope with advances in information technology may be dismayed by predictions about the rise and impact of robotics. However, a considerable amount of hyperbole, especially from robot manufacturers but also from some robotics researchers, accompanies predictions and assurances in this field, so it is prudent to be wary of claims that run significantly ahead of the technology's successful application. There is considerable debate among roboticists as to what is technologically feasible. Thus, it is important to distinguish between robots already in effective operation, those likely to be available in the near future, those on the distant horizon, those that are not only far-off but also far-fetched, and those that are unduly expensive.

A brief review of publications on ethics and robotics follows this introductory section. The third section, which discusses the evolution of robotics, includes examples of its existing, emerging and possible future manifestations. The fourth section distinguishes between types of robots in terms of their ethical autonomy, and the fifth section examines selected public policy fields involving not only the application of robotics but also significant issues in robot ethics. The final section discusses theoretical and practical considerations in public sector ethics arising from developments in the field of robotics.

The term *robotics* is variously interpreted. It refers here to the science or the study of technology involved in the design, development and deployment of machines, known as robots, to perform tasks normally performed by human beings. Robotics is tightly linked to the concept of *artificial intelligence* which is concerned with the ability of machines, especially robots, to perform tasks that normally require human intelligence, including learning, reasoning and developing ideas. Unlike a computer, a robot is a reprogrammable machine that can obtain information from its environment and take such physical actions as moving around, lifting objects and even engaging in combat. Robots are often described as giving legs and arms to the Internet. Although the physical appearance of robots in humanoid or android form is commonly associated with human beings, robots take diverse forms and sizes. They can "move on land, in the water, in the air, and in space. Terrestrial mobility uses legs, treads, and wheels as well as snake-like locomotion and hopping. Flying robots make use of propellers, jet engines, and wings. Underwater robots may resemble submarines, fish, eels, or even lobsters" (Lin, Bekey and Abney 2008:11).

Writings on robot ethics

There is a huge volume of literature, both fictional and non-fictional, on robots and robotics. While several academic disciplines contribute to the non-fiction works, philosophers, computer scientists and engineers are most prominently featured. Reference is made here to selected writings dealing primarily with the ethical dimension of robotics.

The best-known fictional works are the many publications by Isaac Asimov, the celebrated science-fiction writer who set out his influential "three laws of robotics" for the first time in a short story entitled "Runaround" published in *Astounding Science Fiction* in March 1942 (Asimov 1950):

> First Law: A robot may not injure a human being or, through inaction, allow a human being to come to harm.
> Second Law: A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
> Third Law: A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

In 1983, Asimov added the "Zeroeth Law" to precede the other three laws by providing that "[a] robot may not harm humanity, or, by inaction, allow humanity to come to harm" (1985). In 1994, Roger Clarke added a Meta-law providing that "[a] robot may not act unless its actions are subject to the Laws of Robotics."

Asimov entertains his readers by demonstrating the complications that arise from robots seeking to respect these laws. Moreover, analysis of Asimov's work has spilled over into the non-fiction sphere as many scholars have pointed out the laws' deficiencies (for example, Hirose 1996; Anderson and Anderson 2007; Rosenberg 2008; Murphy and Woods 2009; Singer 2009; Howlader 2011). For example, under the First Law robots might try to prevent humans from taking reasonable risks, and robot soldiers would need to break this law on the battlefield.

Other scholarly writings on robotics appear in a large number of journals, including those directed at a general audience (for example, the *International Journal of Robotics Research*) and those geared to specialists (for example, *the International Journal of Medical Robots and Computer Assisted Surgery*). Professional publications on robotics include the *Robotics Business Review*. While few articles on robotics are aimed at a broad public sector audience, many of them are directly applicable to specific policy fields (for example, healthcare and the military). Publications dealing with both ethics and robotics in public organizations are rare, but many articles on robot ethics published in such journals as the *International Review of Information Ethics* are relevant to both the public and private sectors.

The well-established book literature on robotics in general has been supplemented in recent years by books dealing specifically with ethics and robotics (for example, Wallach and Allen on *Machine Morality: Teaching Robots Right from Wrong* (2009); Capurro and Nagenborg on *Ethics and Robotics* (2009); and Lin, Abney and Bekey on *Robot Ethics: The Ethical and Social Implications of Robotics* (2012). The latter scholars note that while writings on robot ethics date back for decades, only recently has there been sufficient advance in robotic technologies to foster a substantial increase in international concern about this field (ix).

The rise of robotics: The present, the probable and the possible

Timelines tracing the many steps in the evolution of robotics (for example, Isom 2005; Siciliano and Khatib 2008; Robotics Research Group 2013) show that the *concept* of robots dates back as far as ancient Greece and that, as early as 1495, Leonardo da Vinci sketched a mechanical armoured knight resembling a humanoid robot. The *term* robot comes from the Czech word *robata* meaning forced labour or drudgery; it was first used by playwright Karel Capek in his 1921 play "Rossum's Universal Robots."

The emergence of real robots dates from 1954 when George Devol and Joe Engleberger created the first industrial robots. In 1956, the phrase "artificial intelligence" was coined at a conference in Dartmouth. By 2008, the world robot population was estimated at 8.6 million, including 7.3 million service robots compared to 1.3 million industrial robots (Guizzo 2010).

Robots are frequently in the news and increasingly in the headlines. Many people will be aware of such applications as:

- the widespread use of robots in industry for tasks that are dull, dirty or dangerous
- the suite of three Canadian robots, including Canadarm 2, on the International Space Station
- the use of robots in hazardous environments such as chemical spill and radioactive sites
- the development of driverless cars predicted to bring about a dramatic reduction in road accidents
- the use of robots to find and neutralize improvised explosive devices
- the central role of robots in such movies as Terminator, Blade Runner and I, Robot.

Fewer people are likely to be aware of such robotic developments as:

- Honda's ASIMO (Advanced Step in Innovative Mobility) robot is a humanoid robot described as being able to "run, walk on uneven slopes and surfaces, turn smoothly, climb stairs, and reach for and grasp objects. ASIMO can also comprehend and respond to simple voice commands . . . recognize the face of a select group of individuals . . . map its environment and register stationary objects . . . [and] avoid moving obstacles as it moves through its environment" (http://asimo.honda.com/asimo-history/).
- "LS3, a dog-like robot, trots behind a human over rough terrain, carrying up to 180kg of supplies. SUGV, a briefcase-sized robot, can identify a man in a crowd and follow him. There is a flying surveillance drone the weight of a wedding ring, and one that carries 2.7 tonnes of bombs" (The Economist 2012).
- The da Vinci surgical system is a robotically-assisted minimally invasive surgical system used for several types of surgery (http://www.davincisurgery.com).
- South Korea is experimenting in the demilitarized zone with robotic border-security guards that are presently human-operated but have an automatic mode (Merchant 2013).

Even fewer people will know about or find believable such futuristic or controversial predictions as these:

- By 2020, the service robot industry will be the same size as the information technology industry was in 2005 and will provide the same number of jobs (Robotics Research Group 2013).
- "Over the next twenty years, stand-alone robots, and robotic technologies in combination with neurotechnologies and other emerging technologies will contribute to a transformation of human culture. We will be confronted with the difficult challenge of not just monitoring and

managing individual technologies that are each developing rapidly, but also the convergence of many technologies" (Wallach 2012:1).
– Robots will be widely used as romantic companions and sex workers (sexbots) (Levy 2012; Whitby 2012).
– "Police robots equipped with biometrics capabilities and sensors will be able to detect and identify weapons, drugs and faces at a distance (Lin, Abney and Bekey 2011: 945).
– The US Department of Defense has projected that one-third of its fighting forces will be composed of robots by 2015 and the first completely autonomous robot soldiers will be on the battlefield by 2035 (Warren 2006).

There is considerable debate as to when the ethical dimension of robotics will become a major societal concern. Most scholars view the development of robots in the form of autonomous ethical agents as a long-term issue, but many scholars stress the importance of early analysis and action to cope effectively with the ethical implications of advances in robotics. A large number of robotics experts who drew up a roadmap for U.S. robotics in 2013 concluded that "we are still 10 to 15 years away from a wide variety of applications and solutions incorporating full-scale general autonomous functionality." However, "the technology has sufficiently progressed to enable an increasing number of limited scale and/or semi-autonomous solutions that are pragmatic, affordable, and provide real value" (Robotics VO, 64).

Typologies of robot ethics

Telerobots are distinguished from *autonomous* robots (Sullins 2006: 25–6). Telerobots are controlled by their operator and require little in the way of artificial intelligence (for example, NASA's Mars Rovers, the da Vinci surgical robot). George Bekey argues that a *fully* remote-controlled machine is not really a robot. For him a robot is "a machine, situated in the world, that senses, thinks and acts. . . . [T]he generally accepted idea of a robot depends critically on the notion that it exhibits some degree of autonomy, or can "think" for itself, making its own decisions to act upon its environment"(2012: 18). *Autonomous* robots have the ability to use their own programming to make some of the major decisions about their behaviour, ranging from the simple decisions of a robot vacuum to such complex decisions requiring ethical reasoning as to how a robotic caregiver should interact with a care recipient.

Typologies of robot ethics are helpful in illuminating differences in the degree of ethical autonomy that robots can or might exercise. Gianmarco Veruggio and Keith Abney (2012: 347–8) divide robot ethics into three categories. The first category is widely described as *roboethics* – a term invented by Veruggio in 2002 to designate a field of applied ethics aimed at developing scientific, cultural and technical tools to foster robotics that will benefit human beings and avoid harming them (Ibid: 348). This category focuses on the ethics of the designers, manufacturers, programmers and users of robots. The second category involves the ethical behaviour of the robots themselves resulting from their adherence to the ethical code that humans have programmed into them. The third category comprises robots engaged in ethical reasoning and making ethical decisions on their own. This third sense of robot ethics, widely described as *machine ethics* or *machine morality* is a new field of inquiry concerned with the development of robots as Artificial Moral Agents (AMAs) (also described as autonomous ethical agents). "The ultimate goal of machine ethics . . . is to create a machine that *itself* follows an ideal ethical principle or set of principles; that is to say, it is guided by this principle or these principles in decisions it makes about possible courses of action it could take" (Anderson and Anderson 2007: 15; italics in original). Some scholars treat machine ethics as distinct from, rather than as a type of, robot ethics. Wallach (2011: 196), for example, asserts that robot ethics "addresses societal concerns in the deployment of robots" whereas machine ethics "considers the prospects for developing machines that are explicit moral reasoners."

Patrick Lin, George Bekey and Keith Abney (2008) distinguish between robots with *operational morality* and those with *functional morality*. The former are very limited in the scope of their operation and are under the complete control of their designers and users. These robots cannot conduct an explicit evaluation of the effects of their actions and do not, therefore, have to assess the rules to apply in specific circumstances or choose among conflicting rules. In contrast, sophisticated robots exercising substantial autonomy will need functional morality that entails "greater sensitivity to the moral factors impinging upon the course of actions available to them" and "the capacity for assessing and responding to moral considerations" (Ibid, 26). Asimov's robots exercise functional morality.

James Moor (2009:12) identifies four types of ethical robots (agents):

Ethical impact agents are those "whose actions have ethical consequences whether intended or not."
Implicit ethical agents "have ethical considerations built into (that is, implicit in) their design" (usually to ensure safety or security as with the warning devices of airplanes).
Explicit ethical agents "can identify and process ethical information about a variety of situations and make sensitive determinations about what should be done." They are viewed as "acting *from* ethics" rather than "*according to* ethics."
Full ethical agents have the metaphysical features usually associated with human beings (that is, consciousness, intentionality and free will).

These typologies suggest that the extent to which robots possess ethical autonomy can be depicted on a continuum from those with no autonomy, through a range of increasingly autonomous ones, to those that are fully autonomous. Major stages along this ethical autonomy continuum are these:

1. Humans make any necessary ethical determinations for the robots by remote control (telerobotics)
2. Humans design and program robots to follow specified rules (operational morality, implicit ethical agency)
3. Humans design and program robots with varying degrees of ethical autonomy (functional morality, explicit ethical agency)
4. Humans design and program robots with full ethical autonomy to enable the robots to act as autonomous ethical agents making their own ethical decisions (functional morality, full ethical agency).

The current focus of robotics research and application is on the first two stages, but it is not too early to contemplate the impact of the third category. Moreover, while it is widely recognized that full moral agency for robots is unlikely to be realized in the foreseeable future (for example, Borenstein and Pearson 2010: 283; Moor 2009: 13), if at all, its implications are already receiving serious and increasing scholarly attention (for example, Asaro 2006: 11–12; Wallach and Allen 2009; Allen and Wallach 2012; Lin, Abney and Bekey 2012), including debate on robots' rights and responsibilities (Levy 2009; Whitby 2008).

Ethics and robots in government

Many of the actual and anticipated advances in robotics have important implications for governments. They will use robotics to foster improved and lower-cost service delivery, and they will expand their regulatory regimes to ensure ethical behaviour in the design and use of robotics by both government and non-government organizations.

Future advances in robotics will be closely linked to the development of the *Internet of Things* (IoT) (Turcu, Turcu and Gaitan 2012). The IoT refers to a world "in which everyday objects such as phones, cars, household appliances, clothes and even food are wirelessly connected to the Internet through smart chips, and can collect and share data" (European Commission 2012:1). The IoT is envisaged as a world-wide network of machine-to-machine communications connecting anything to anyone at any time and in any place. This vision is succinctly captured in Cisco Systems' widely publicized focus on the implications of "The Internet of Everything" that it describes as "the intelligent connection of people, process, data and things to create new value and opportunities" (http://www.cisco.com/web/about/ac79/innov/IoE.html). Robots with the capability to sense, think and/or act are expected to be integrated into the IoT and to fuel innovative initiatives in such policy fields as energy and healthcare.

The three policy fields discussed below – aging, health care and the military – fall into the sphere of service robots which can be divided into *personal* or *domestic* services such as homecare and healthcare assistance and *professional* services such as defence and transportation (Robotics VO 2013:63).

Aging and robotics

In many countries, the proportion of elderly persons in the population is increasing and the number of available caregivers in the workforce is expected to fall as a result of declining birthrates. This has led some governments (those of Japan and South Korea in particular) to consider substantial use of robots as caregivers and therapeutic companions and, as discussed below, as healthcare assistants ("robotic nurses" or "nursebots") for elderly persons. The anticipated benefits of using robotics for elder care and companionship (Forlizzi, DiSalvo and Gemperle 2004; Sharkey and Sharkey 2012a, 2012(b); Sparrow and Sparrow 2006; Decker 2008; Borenstein and Pearson 2010) include

1. monitoring frail or mentally challenged elderly persons to help them stay longer in their homes before moving to institutional care ("aging in place");
2. assisting all elderly persons to stay in their homes longer by helping them with such tasks as washing, dressing, feeding, and moving around;
3. assisting the elderly and their caregivers with such time-consuming tasks once the elderly have moved into care facilities;
4. helping the elderly clean and groom their property (for example, using robot vacuum cleaners and lawn mowers); and
5. providing robot companions for elderly persons who are depressed or socially isolated.

Among the growing number of robots created for such purposes is CareBot – the Family Care and Personal Assistance Robot – which, according to Gecko Systems, can monitor elderly persons, give them automatic reminders (for example, when to take medications), notify emergency contacts, and provide companionship (for example, engage in limited conversation). Sharkey and Sharkey (2012a: 287) predict that within the next ten years the elderly are likely to be able to acquire at a fair price robotic technologies that will help with such tasks as cleaning, feeding and basic hygiene. The elderly already have access to robot companion pets, including the popular Paro (an abbreviation of the Japanese word for personal robot). Paro is a furry, cuddly lifelike robotic seal developed for elderly persons that responds to being petted and to sounds by moving its head and legs and making baby seal noises.

Academic scholars differ on the extent to which they endorse robotic home care and companionship for elderly persons. While robots are recognized as bringing such benefits as staving off institutional care and providing some measure of companionship, most scholars express concern about the attendant ethical ramifications, including the invasion of privacy (for example, from robots enabling remote electronic surveillance of elderly persons bathing or dressing) and feelings of a loss of control (for example, when caregivers use robots insensitively to wash or move elderly persons). There are especially strong objections to the use of robot companions that reduce the human contact and attention the elderly need for a sense of well-being (Sparrow and Sparrow 2006; Decker 2008, Coeckelbergh 2010). It is argued that robots should only be used as assistants or supplements to human caregivers, not as replacements. Caregivers need to distinguish between using robots to foster the physical or psychological well-being of the elderly and using them to lighten the caregivers' workload or cut costs. "Society has a duty to ensure that no elderly person is left in the exclusive company of machines" (Sharkey and Sharkey 2012a: 287). A related issue requiring more research is the extent to which elderly persons will anthropomorphize[1] humanoid, pet or doll robots and whether such emotional attachment should be encouraged (Borenstein and Pearson 2010: 252, 254; Duffy 2003).

Caregivers need to distinguish between using robots to foster the physical or psychological well-being of the elderly and using them to lighten the caregivers' workload or cut costs

There is concern that in caring for elderly people, particularly those with dementia, the effectiveness of robot companions depends on deceiving these people with the illusion of reality. One view is that such deception is immoral (Sparrow and Sparrow 2006: 156) and constitutes "disrespectful deceit" (Borenstein and Pearson 2010: 185). Another view (Sharkey and Sharkey 2012b: 36) is that robot companions, if used cautiously, could perk up the lives of elderly persons and promote increased social interaction. Preliminary findings of a Canadian study on the use of Paro robots in a long-term care facility were that using "social commitment robots" like Paro "may be clinically valuable for older, agitated persons living with dementia and, also, beneficial to family members and staff" (Roger et al 2012: 92).

If advances in robotics move closer to the vision of machine morality with autonomous robots outlined above, other ethical issues arise. For example, how far should robots go to prevent elderly persons from harming themselves? How persistent should robots be in reminding elderly persons to take their medication? A broad ethical question covering all forms and levels of robot care is whether elderly persons should be able to give consent – to have the final say on the extent to which they receive robot care.

Health care and medical robotics

Several benefits of using robotics in elder care also apply to the health care field and offer benefits to the general population as well the elderly. For example, robots are being designed to assist ill or impaired persons of any age to stay in their homes and to help nurses care for them if they are hospitalized. These benefits are accompanied by some of the same ethical issues discussed above, including loss of control and reduced human contact.

The health and medical applications of robotics "include surgery, rehabilitation therapy, prosthetics and orthotics, medical imaging, monitoring and therapeutic assistance" (Computing Community Consortium 2009: 79). The cost of these services is projected to rise dramatically over the next several decades. To constrain these costs, governments are beginning to look to innovations in robotics. In 2013, the U.S. Food and Drug Administration approved for hospital use RP-VITA – an iPad-controlled robot with a video screen that can be sent to patients' bedsides to enable them to communicate with their doctor who is at a remote location (Hornyak 2013). And more than 80 hospitals are using Pyxis HelpMate SP robots that can navigate smoothly and autonomously from floor to floor and room to room delivering drugs, meals, medical records, laboratory specimens, and supplies, thereby reducing delivery costs and freeing up nursing and pharmacy staff to focus more on patient care (NASA 2011).

The use of robots for medical procedures has grown significantly in recent years. For example, the da Vinci robot surgical system (developed by Intuitive Surgical Systems) and similar telerobots enable surgeons to conduct minimally invasive surgery with greater dexterity and to perform delicate procedures that would be very difficult without robotic help. The use of surgical robotics can also reduce the number of complications and foster quicker recovery time for patients, thereby cutting costs. However, important ethical issues arise in respect of the extent to which safety precautions (for example, redundancy measures) are taken to avoid patient injury (Taylor et al 2008: 1207; Datteri 2013). How much risk should medical authorities take in permitting robotic-assisted surgery? Should a robot surgeon ever be used if the risk is greater than using a human surgeon? In the future, robots are expected to be able to exercise greater autonomy in performing surgical procedures, but who is responsible if something goes wrong – the robot's designer, its manufacturer, the hospital, individual surgeons?

Defence and robotics

A similar question about responsibility arises if something goes amiss with the deployment of robots in warfare. With whom does responsibility lie – with the robot's designer, its programmer, its operator? Such ethical issues are front and centre in the U.S. military's management of unmanned aerial, ground and underwater robotic systems. The striking variety of military robots already in operation or under development raise difficult ethical issues, including, for example, the moral implications of injuries to non-combatants resulting from extensive deployment of drones against terrorists. According to the U.S. Department of Defense (DOD), decisions regarding the ethical use of force and individual targeting by unmanned systems will for the foreseeable future be kept under human control (Robotics VO 2013: 114). This is in keeping with predictions for robot deployment in general. Capurro and Nagenborg, for example, assert that on the basis of current technology "[r]obots are and will remain for the foreseeable future dependent on human ethical scrutiny as well as on the moral and legal responsibility of humans" (quoted in Crnkovic, Dodig and Curuklu 2012: 62).

There is, however, enormous pressure to use autonomous robots on the battlefield so as to reduce or eliminate the risk to human soldiers by enabling them to wage war at a distance – to be "cubicle warriors" using "stand-ins"

There is, however, enormous pressure to use autonomous robots on the battlefield so as to reduce or eliminate the risk to human soldiers by enabling them to wage war at a distance – to be "cubicle warriors" using "stand-ins". While DOD recognizes that enabling unmanned systems to exercise autonomy must not undermine such factors as safety and reliability, it acknowledges that unmanned systems will only be able to fully achieve their potential if they do realize a high degree of autonomy (Robotics VO 2013: 119). Many ethical issues would arise from the deployment of increasingly autonomous military robots (see Lin 2011). Some scholars (Sparrow 2007) argue that deploying such "killer robots" is immoral, but Lokhorst and van den Hoven (2012: 148) describe the use of this term as "an insidious rhetorical move" and note that robots can disarm or immobilize rather than kill enemy soldiers, and that in some circumstances the actions of robot soldiers can be morally superior to those of human soldiers. They also contend, however, that the several human actors involved in the design, development or deployment of robots cannot "transfer moral responsibility to their products in case of untoward outcomes or . . . claim diminished responsibility for the consequences brought about by their products" (Ibid: 154).

Much debate has centred on Ronald Arkin's proposal for an "ethical governor" – "an ethical control and reasoning system potentially suitable for constraining lethal actions in an autonomous robotic system so that they fall within the bounds described by the Laws of War and Rules of Engagement" (2007: 1). Other scholars (for example, Sparrow 2007; Sharkey 2012) strongly question both the desirability and the feasibility of Arkin's proposal. Andreas Matthias warns that "[t]he misconception about the capabilities and aims of the ethical governor is . . . misleading and more dangerous than the absence of such a device (and the resulting placement of humans in morally critical places of control) would be" (2011: 17).

The prospect of military robots with substantial ethical autonomy gives rise to such questions as these:

– Will autonomous robots be able to follow established guidelines of the Laws of War and Rules of Engagement, as specified in the Geneva Conventions?
– Will robots know the difference between military and civilian personnel?
– Will they recognize a wounded soldier and refrain from shooting? (Lin, Bekey and Abney 2008: 21).

Countries using military robotics in combat roles face more serious ethical issues than those using them for such purposes as surveillance or reconnaissance. D.F. Holman, for example, suggests that in Canada surveillance, ground attack and air combat are the most plausible applications of unmanned aerial vehicles but surveillance, especially in Canada's north, is the most likely application (2013).

Robot ethics: Theoretical and practical considerations

The potentially lethal consequences of deploying certain military robots illustrate the importance of the ethical dimension of robotics. The increasing variety of robots includes machines that can have such negative effects as bodily injury, invasion of privacy or reduced human contact. Not only philosophers but also scholars from a wide range of other disciplines, together with those persons involved in developing and deploying robots, need to be mindful of the ethical issues raised by robotics. Reference to the leading ethical theories – deontology, consequentialism and virtue ethics – as well as other ethical theories such as contractarianism informs decisions as to whether robots should be used at all in certain circumstances (for example, as therapeutic companions) and the limitations that should be placed on their use (for example, avoiding invasions of privacy). The ethical questions raised earlier for robotics use in the three policy fields are illustrative of a wide range of concerns that can arise and that can be examined through the lenses of various ethical theories. The application of these theories to public policy issues is a large subject requiring separate treatment.

An emerging issue that is receiving increased scholarly attention is the degree of ethical autonomy that robots should be permitted to exercise (for example, autonomous robot soldiers). Anderson and Anderson note that "machines with a level of autonomy requiring ethical deliberation are here and both their number and level of autonomy are likely to increase" (2007:18). Wallach acknowledges that robots may at some point reach the stage of autonomous ethical agents, but cautions that there are many technological and philosophical thresholds to be overcome and some of these thresholds "may turn out to be ceilings that define limits to the intelligence and moral understanding of (ro)bots" (196).

The complexity of applying ethical theories to the use of robotics increases with movement along the ethical autonomy continuum. To the traditional debate as to which theory or combination of theories is preferable as a basis for ethical decision making is added the challenge of programming appropriate ethical principles and rules into the robots. To what extent are the various theories computable? Even Asimov's three laws, which at first glance seem simple and straightforward, pose difficult programming issues. Can the principles or rules associated with a particular ethical theory effectively inform the design of algorithms to implement ethical decision making by robots?

Robotics scholars are not agreed on how easily this can be done or on which ethical theory is best suited for this purpose. Abney (2012: 41–5) assesses the relative benefits of the three major ethical theories, with particular reference to building artificial moral agents and concludes that robotics programming – the artificial intelligence or control software built into the robots – is not sufficiently advanced to permit the effective application of the theories. He does assert that a hybrid system, based on virtue ethics, of top-down rules combined with bottom-up machine learning offers the best theoretical approach. Wallach and Allen (2009: 117ff) view virtue ethics as more computable than deontology or utilitarianism, but Tonkens (2012: 137) argues that a virtue-based moral framework may be useful for such near-term initiatives as "designing systems that are sensitive to moral considerations" but not for application to autonomous artificial moral agents. Anderson and Anderson apply to machine ethics the prima facie duty approach that combines the good features of both the deontological and teleological approaches. "A theory with several prima facie duties (obligations that we should try to satisfy, but which can be overridden on occasion by stronger obligations) – some concerned with the consequences of actions and others concerned with justice and rights – better acknowledges the complexities of ethical decision making than a single absolute duty theory" (2007: 18).

These theoretical considerations inform the practical issue of whether a code of ethics for the use of robotics in public organizations is required and, if so, what its content should be. Some roboticists argue that there is already a pressing need for codes. Blay Whitby notes, with respect to the technologies of robot nannies and of smart homes (including the monitoring of occupants), that "the need for ethical codes that give guidance is immediate, if not already overdue" (2012: 243).

Much attention was given to the 2007 announcement by the Robot Division of South Korea's Ministry of Commerce, Industry and Energy that it would develop a Robot Ethics Charter. The draft Charter, which has not been finalized, contains standards for robotic manufacturers and users and guidelines on ethical principles to be programmed into robots to govern human-robot interaction (Lovgren 2007). To overcome the deficiencies of Asimov's Three Laws, Murphy and Woods (2009) proposed the Three Laws of Responsible Robotics, including the provision that "[a] human may not deploy a robot without the human–robot work system meeting the highest legal and professional standards of safety and ethics." And in 2011 the UK's Engineering and Physical Sciences Research Council and the Arts and Humanities Research Council (Stewart 2011) prepared the following draft code of ethics:

1. Robots should not be designed solely or primarily to kill or harm humans.
2. Humans, not robots, are responsible agents. Robots are tools designed to achieve human goals.
3. Robots should be designed in ways that assure their safety and security.
4. Robots are artefacts; they should not be designed to exploit vulnerable users by evoking an emotional response or dependency. It should always be possible to tell a robot from a human.
5. It should always be possible to find out who is legally responsible for a robot.

These principles echo several of the points discussed in this article and indicate the likely difficulty of getting agreement among the central actors on the content not only of a code but also of policy documents, legislation and regulations dealing with robotics.

Such broadly worded principles provide a valuable basis for considering the appropriate content of robotics codes, but much greater specificity will be required in codes developed to meet the particular needs of public organizations. Do governments require a separate robotics code or could guidance for the design and use of robots be incorporated into existing codes or covered in policy statements, or both? Learning points can be drawn from the approaches that public organizations have taken to managing the ethical implications of digital technologies. The Government of Canada, for example, has not created a separate ethics code for this purpose or dealt with it in its Values and Ethics Code, but has adopted a *Guideline for External Use of Web 2.0* (Treasury Board of Canada Secretariat 2011) and several related policy documents. Some federal departments, however, have revised their codes of ethics to take account of advances in information technology. Certain departments, defence for example, could adopt their own code of robot ethics, but the provisions of a broadly applicable robotics code could be adapted to the needs of each department. A popular approach to the design of public sector ethics codes (and those of private, third sector and professional organizations as well) is a two-part code that supplements service-wide guidance with department-specific provisions. Another important consideration is that many public servants are members of professions like engineering or computer science that are likely to develop their own robotics codes. Thus attention must be paid to potential tension between public service and professional codes dealing with robotics.

Conclusions

Robots are on the rise. A diverse assortment of robots, with varying purposes, capacities, forms, and sizes, is emerging. Some experts anticipate that within a decade or two robots will, like present-day computers, be commonplace. Philosophers, especially ethicists, are assessing the work of engineers and computer scientists on the design and manufacture of a striking variety of service robots and the decisions of a growing number of public and private sector organizations on the robots' operation and application. For an adequate view of the overall effects of robotics developments, roboticists in these three fields need to collaborate increasingly with psychologists, economists, sociologists, political scientists, and both business and public management experts.

Since research and development in robotics, whether by governments or the private sector, requires large investment, governments are well advised to pursue collaborative and targeted initiatives with the business and university sectors. Note in this regard that the Canadian Field Robotics Network (NCFRN) is bringing together government, academic and industrial researchers to develop robotics technologies for such purposes as "monitoring and maintaining the state of our environmental heritage, patrolling borders (for example, in the Arctic), dealing with environmental disasters (for example, oil spills and nuclear accidents), or improving the quality of life of senior citizens" (http://ncfrn.mcgill.ca). (NFCRN is funded by the federal government through the National Science and Engineering Council of Canada.) Collaboration is envisaged as extending to the robots themselves with, for example, swimming and flying robots working together to measure icebergs so as to reduce their danger to shipping and underwater cables. A notable collaborative initiative outside Canada is the CompanionAble project, a public-private partnership in the European Union dedicated to creating a robotic assistant that collaborates with a smart home and remote control centre to provide affordable and comprehensive homecare for the elderly.

Advances in robotics will have widespread implications for the policy, service and regulatory responsibilities of government

The accelerated advancement of robotics technology, especially the rapidly growing use of service robots, has heightened concern about the field's ethical dimension. The development of increasingly autonomous robots will further heighten this concern, but substantial movement along the autonomy continuum towards machine ethics is not imminent and, according to some roboticists, is either a distant or unlikely prospect. The near-term focus is on the ethical standards and behaviour of those involved in designing, manufacturing, programming and operating robots. Governments will play a large role in promoting the responsible conduct of these activities. Given the unpredictable or unanticipated consequences of some robotic activities, it is appropriate for governments to heed the ethical precepts of the precautionary principle. This principle requires that decision makers take precautions when, in the absence of scientific certainty, an activity raises concerns about harm to the health of humans or the environment. The principle also requires that the burden of proof for conducting an activity rests with the persons promoting it (for example, robot operators) rather than those harmed or possibly harmed by it, and that those affected by an activity (for example, elderly persons assisted by robots) should be able to give informed consent.

Advances in robotics will have widespread implications for the policy, service and regulatory responsibilities of government. Strategic and policy planning will increasingly have to take account of these advances and the possible solutions that robotics offers in various policy fields. As noted above, the fields of aging, health and defence are already significantly engaged with robotics, but many other policy fields are beginning to feel its effects. The use of service robots has enormous potential to improve service to citizens and cut costs. However, most service robots available on a commercial basis are still prohibitively expensive. The development of regulations for service robotics will soon supplement the considerable volume of those already adopted for industrial and medical robotics.

Many of the issues raised by robotics in respect of such matters as privacy, security, safety and accountability have a significant legal aspect. Ensuring personal privacy protection in today's technological society has become increasingly difficult. This challenge will be considerably heightened by the growing privacy threat posed by robotics used for such purposes as direct surveillance, providing "new points of access to historically protected spaces" (for example, the home), and extracting and transmitting information on how individuals lead their lives (Calo 2012: 187–8). In meeting this challenge, governments will also have to ensure that privacy regulations do not unduly discourage innovative and entrepreneurial robotics initiatives.

Several key topics in contemporary public sector ethics, including personal moral responsibility, privacy, accountability, and managing ethical conduct are also central to the emerging field of robot ethics. The rise of robotics strengthens the case not just for ethics codes but also for attention to other means of promoting ethical conduct, including ethics training and education. Contemplating the appropriate ethical principles for guiding or programming robots at each stage of the ethical autonomy continuum illuminates the differences and relationships among ethical theories. It also provides a learning opportunity by obliging theorists to consider the practical effects of applying their preferred theory, not only in the robotics context but also in general. Finally, it helps to signal the extent to which the management of robots in and by public organizations will require resort to more coercive governing instruments such as rules, regulations and legislation.

Note

1 Anthropomorphism is the attribution of human traits or behaviour to objects or animals.

References

Abney, Keith. 2012. "Robotics, ethical theory and metaethics: A guide for the perplexed." In *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Patrick Lin, Keith Abney and George A. Bekey. Cambridge. Mass.: MIT Press, pp. 39–52.

Allen, Colin, and Wendell Wallach. 2012. "Moral machines: Contradiction in terms or abdication of human responsibility." In *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Patrick Lin, Keith Abney and George A. Bekey. Cambridge. Mass.: MIT Press, pp. 55–68.

Anderson, Michael, and Susan Leigh Anderson. 2007. "Machine ethics: Creating an ethical intelligent agent." *AI Magazine* 28 (4): 15–26.

Arkin, Ronald. (2007). *Governing Lethal Behavior: Embedding Ethics in a Hybrid Deliberative/Reactive Robot Architecture. Part 3: Representational and Architectural Considerations*. Available at: http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=52B9156631002C98A1D787BD3E6154F6?doi=10.1.1.110.1610&rep=rep1&type=pdf

Asaro, Peter M. 2006. "What should we want from a robot ethic?" *International Review of Information Ethics*, 6: 9–16.

Asimov, Isaac. 1950. *I, Robot*. Gnome Press.

——. 1985. *Robots and Empire*. Doubleday Books.

Bekey, George A. 2012. "Current trends in robotics: Technology and ethics." In. *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Patrick Lin, Keith Abney and George A. Bekey. Cambridge. Mass.: MIT Press, pp. 17–34.

Borenstein, Jason, and Yvette Pearson. 2010. "Robot caregivers: Harbingers of expanded freedom for all?" *Ethics of Information Technology* 12: 277–88.

Calo, M. Ryan. 2012. "Robots and privacy." In *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Patrick Lin, Keith Abney and George A. Bekey. Cambridge. Mass.: MIT Press, pp. 187–201.

Capurro, R., and M. Nagenborg. 2009. *Ethics and Robotics*. Amsterdam: IOS Press.

Clarke, Roger. 1994. "Asimov's laws of robotics: Implications for information technology." *Roger Clarke's Web-Site*. Available at: http://www.anu.edu.au/people/Roger.Clarke/SOS/Asimov.html.

Coeckelbergh, Mark. 2010. "Health care, capabilities, and AI assistive technologies." *Ethical Theory and Moral Practice* 13: 181–90.

Computing Community Consortium. 2009 (May 21). *A Roadmap for US Robotics: From Internet to Robotics*. Available at: http://www.usrobotics.us/reports/CCC%20Report.pdf.

Crnkovic, Gordana Dodig, and Baran Curuklu. 2012. "Robots: Ethical by design." *Ethics and Information Technology* 14: 61–72.

Datteri, Edoardo. 2013. "Predicting the long-term effects of human-robot interaction: A reflection on responsibility in medical robotics." *Science and Engineering Ethics* 19: 139–60.

Decker, Michael. 2008. "Caregiving robots and ethical reflection: The perspective of interdisciplinary technology assessment." *Artificial Intelligence & Society* 22 (3):3315–30.

Duffy, Brian R. 2003 (March). "Anthropomorphism and the social robot." *Robotics and Autonomous Systems* 42 (3–4): 177–90.

European Commission. 2012 (April 12). Digital Agenda: Commission consults on rules for wirelessly connected devices – the "Internet of Things." Brussels. Available at: http://europa.eu/rapid/press-release_IP-12-360_en.htm.

Forlizzi, Jodi, Carl DiSalvo, and Francine Gemperle. 2004. "Assistive robotics and an ecology of elders living independently in their homes." *Human-Computer Interaction*, 19: 25–59.

Gates, Bill. 2007 (January). "A robot in every home." *Scientific American*, 58–65. Available at: http://www.scientificamerican.com/article.cfm?id=a-robot-in-every-home.

Guizzo, Erico. 2010. "World robot population reaches 8.6 million." IEEE Spectrum. Available at: http://spectrum.ieee.org/automaton/robotics/industrial-robots/041410-world-robot-population.

Hirose, Shigeo. 1996. "A code of conduct for robots coexisting with human beings." *Robotics and Autonomous Systems* 18: 101–07. Available at: http://www.sciencedirect.com/science/article/pii/0921889095000747.

Holman, D.F. 2013 (August). *The Future of Drones in Canada: Perspectives from a Former RCAF Fighter Pilot*. Canadian International Council and Canadian Defence and Foreign Affairs Institute. Available at: http://opencanada.org/wp-content/uploads/2013/08/SL12CIC017-SSWGP-Holman-v3.pdf.

Hornyak, Tim. 2013 (January 9). "Medical robot RP-VITA gets FDA approval." CNET. Available at: http://ces.cnet.com/8301-34441_1-57563095/medical-robot-rp-vita-gets-fda-approval.

Howlader, Daniel. 2011. "Moral and ethical questions for robotics public policy." *Synesis: A Journal of Science, Technology, Ethics, and Policy* G.1–G.6.

Isom, James. 2005. Robotics Laboratory. *A Brief History of Robotics*. Available at: robotics.megagiant.com/history.html.

Levy, David. 2009. "The ethical treatment of artificially conscious robots." *International Journal of Social Robotics* 1 (3): 209–16.

——. 2012. "The ethics of robot prostitutes." In *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Lin, Patrick, Keith Abney and George A. Bekey. Cambridge, Mass: MIT Press, pp. 223–31.

Lin, Patrick. 2011 (December 15). "Drone-ethics briefing: What a leading robot expert told the CIA." *The Atlantic*. Available at: http://www.theatlantic.com/technology/archive/2011/12/drone-ethics-briefing-what-a-leading-robot-expert-told-the-cia/250060.

Lin, Patrick, George Bekey, and Keith Abney. 2008 (December 20). *Autonomous Military Robotics: Risk, Ethics and Design*. San Louis Obispo: California Polytechnic State University. Available at: http://ethics.calpoly.edu/ONR_report.pdf.

Lin, Patrick, Keith Abney, and George Bekey. 2011. "Robot ethics: Mapping the issues for a mechanized world." *Artificial Intelligence* 175: 942–949.

Lin, Patrick, Keith Abney, and George A. Bekey, eds. 2012. *Robot Ethics: The Ethical and Social Implications of Robotics*. Cambridge, Mass: MIT Press.

Lokhorst, Gert-Jan, and Jeroen van den Hoven. 2012. "Responsibility for military robots." In *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Lin, Patrick, Keith Abney and George Bekey. Cambridge, Mass: MIT Press, pp. 145–56.

Lovgren, Stefan. 2007 (March 16). "Robot code of ethics to prevent android abuse, protect humans." *National Geographic News*. Available at: http://news.nationalgeographic.com/news/2007/03/070316-robot-ethics.html

Matthias, Andreas. 2011. "Is the Concept of an Ethical Governor Philosophically Sound?" Proceedings of the TIL Ting Perspectives 2011, Tilburg University, Netherlands. Available at: http://www.academia.edu/473656/Is_the_Concept_of_an_Ethical_Governor_Philosophically_Sound

Merchant, Brian. (2013). "These killer autonomous robots are already switched on." Motherboard. Available at: http://motherboard.vice.com/blog/these-killer-autonomous-robots-are-already-in-the-trenches.

Moor, James H. 2009 (March/April). "Four Kinds of Ethical Robots." *Philosophy Now*, 72: 12–14. Available at: http://philosophynow.org/issues/72/Four_Kinds_of_Ethical_Robots.

Murphy, Robin, and David D. Woods. 2009 (July/August). "Beyond Asimov: Three laws of responsible robotics." *Intelligent Systems* 24 (4): 14–20. Available at: http://cmapsinternal.ihmc.us/rid=1JD6BQHJT-139V14J-L2D/36.%20Laws%20of%20Robotics%20(WoodsMurphy).pdf.

NASA. 2011. "A robot to make the rounds." Available at: http://spinoff.nasa.gov/spinoff2003/hm_4.html.

Robotics Research Group. 2013. *Robotics History Timeline*. Available at: http://robotics.ece.auckland.ac.nz/index.php?option=com_content&task=view&id=31

Robotics VO. 2013 (March 20). *A Roadmap for US Robotics: From Internet to Robotics, 2013 Edition*. Available at: http://www.cra.org/ccc/files/docs/2013-Robotics-Roadmap.

Roger, K., L. Guse, E. Murdoch, and A. Osterreicher. 2012. "Social commitment robots and dementia." *Canadian Journal of Aging* 31 (1): 87–94.

Rosenberg, Richard S. 2008. "The social impact of intelligent artefacts." *AI and Society* 22: 367–83.

Scheutz, Matthias. 2012. "The inherent dangers of unidirectional emotional bonds between humans and social robots." In *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Lin, Patrick, Keith Abney and George Bekey. Cambridge, Mass: MIT Press, pp. 205–21.

Sharkey, Noel. (2012). "Killing made easy: From joysticks to politics." In *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Lin, Patrick, Keith Abney, and George Bekey. Cambridge, Mass: MIT Press, pp. 111–128.

Sharkey, Noel, and Amanda Sharkey. 2012a. "The eldercare factory." *Gerontology* 58: 282–88.

Sharkey, Amanda, and Noel Sharkey. 2012b. "Granny and the robots: Ethical issues in robot care for the elderly." *Ethics and Information Technology* 14: 27–40.

Siciliano, Bruno, and Oussama Khatib, eds. 2008. *Springer Handbook of Robotics*. Berlin: Springer.

Singer, Peter W. 2009 (May 18). "Isaac Asimov's Laws of Robotics are wrong." Brookings Institution. Available at: http://www.brookings.edu/research/opinions/2009/05/18-robots-singer.

Sparrow, Robert. 2007. "Killer robots." *Journal of Applied Philosophy* 24 (1): 62–77.

Sparrow, Robert, and Linda Sparrow. 2006. "In the hands of machines? The future of aged care." *Minds and Machines* 16: 141–61.

Stewart, Jon. 2011. "Ready for the robot revolution?" *BBC News: Technology*. Available at: http://www.bbc.co.uk/news/technology-15146053.

Sullins, John P. 2006. "When is a robot a moral agent?" *International Review of Information Ethics* 6: 24–30.

Taylor, Russell H., Arianna Menciassi, Gabor Fichtinger, and Paolo Dario. 2008. "Medical Robotics and Computer-Integrated Surgery." In *Springer Handbook of Robotics*, edited by Siciliano, Bruno and Oussama Khatib. Berlin: Springer, pp. 1199–1222.

The Economist. 2012 (June 2). "Morals and the machine." Available at: http://www.economist.com/node/21556234.

Tonkens, Ryan. 2012. "Out of character: On the creation of virtuous machines." *Ethics of Information Technology* 14: 137–49.

Treasury Board of Canada Secretariat. 2011. *Guideline for External Use of Web 2.0*. Available at: http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=24835&section=text

Turcu, Cristina, Cornel Turcu, and Vasile Gaitan. 2012. "Integrating robots into the Internet of Things." *International Journal of Circuits, Systems and Signal Processing* 6 (6): 430–37.

Veruggio, Gianmarco, and Keith Abney. 2012. "Roboethics: The applied ethics for a new science." In *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Lin, Patrick, Keith Abney and George A. Bekey. Cambridge. Mass.: MIT Press, pp. 347–63.

Wallach, Wendell. 2011. "From robots to techno sapiens: Ethics, law and public policy in the development of robotics and neurotechnologies." *Law, Innovation and Technology* 3 (2): 185–207.

Wallach, Wendell. 2012 (April 27). "Issues in the development of robotics and neurotechnologies." Institute for Ethics and Emerging Technologies. Available at: http://ieet.org/index.php/IEET/more/wallach20120427.

Warren, Pete. 2006 (October 26). "Launching a new kind of warfare." *The Guardian*. Available at: http://www.theguardian.com/technology/2006/oct/26/guardianweeklytechnologysection.robots.

Whitby, Blay. 2012. "Do you want a robot lover: The ethics of caring technologies." In *Robot Ethics: The Ethical and Social Implications of Robotics*, edited by Lin, Patrick, Keith Abney and George A. Bekey. Cambridge. Mass.: MIT Press, pp. 233–48.

——. 2008. "Sometimes it's hard to be a robot: A call for action on the ethics of abusing artificial agents." *Interacting with Computers* 20: 326–33.