Emerging Medical Ethical Issues in Healthcare and Medical Robotics

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Abstract—**Due to the increasing sophistication and complexity of autonomous machines, Artificial Intelligence, Computerized Decision Support Systems (CDSS), natural language question-answering robots, and social / emotive medical robots, new medical ethics conundrums are arising. Unresolved questions revolve around autonomy, responsibility, empathy, trust, moral agency and the social and economic impacts of medical robots.**

Index Terms—**robotic ethics; medical and healthcare robots; technology and morality**

I. Introduction

The term 'robot' is becoming increasingly difficult to define. The origin of the word is generally traced to the Slavic word *robota*, which means "forced labourer." Czech writer Karel Čapek popularized the term in his 1920 play *R.U.R.*, and the etymology of the word reveals a prevalent popular conception of robots that their main function is to relieve mankind of dangerous, repetitive and boring tasks. Čapek's play also introduced a recurrent theme into science fiction literature that an artificially created race could gain autonomy, grow more powerful in intelligence or physical strength, and rise up and destroy its creator, an issue that was discussed in the first phase of robotics ethics. Robots can be loosely defined as autonomous or semi-autonomous machines that carry out tasks automatically, and in some definitions may include software agents.

Table I below, adapted by the author from Schweikard & Ernst [1], provides a suggested taxonomy of robots commonly used in medicine and healthcare. However, due to 'functional convergence' in which robotic machines in conjunction with artificially intelligent software agents can perform multiple tasks and be rearranged in different configurations, categorization of robots must remain fluid. Therefore an examination of the ethical dimension of robotics should avoid a strictly functional approach as well as a purely 'case study' methodology (although these investigations can lead to useful insights into regulatory and legal issues of specific devices), and robot ethics should simultaneously engage abstract principles and imagined potentialities. This contribution uses speculative philosophy to examine current and emergent ethical issues in medical robotics taking into account future possibilities of robotic machines based on extrapolation from current and projected lines of research development.

In the mid-20th century, the first wave of novel medical ethical dilemmas directly related to newly developed machine-aided medical interventions arose with life-prolonging technologies known collectively as Life Support, including such technologies as iron lungs, positive pressure artificial ventilators, and Automated External Defibrillators (AEDs), etc. The ability of medical technology to keep an entire body alive with some organ systems functioning while others clearly unusable (e.g. "brain death") sparked new examinations in sociology, theology, ethics, philosophy, ethics, and law on the meaning and definition of life and the elusive concept of the soul and the essential nature of the individual. For some philosophers, life should be a natural process with death a natural consequence of the human organism. Others, however, argue that man-machine hybrids which extend life are ethical and even desirable, and have the potential to increase human longevity and happiness even in non-disease states. Many technological aids in human health rarely attract attention and are universally accepted, such as eyeglasses, dental fillings, hearing aids, artificial limbs, etc. Only a radical social Darwinist (eugenicist) would argue that assisting the 'weak' with artificial means leads to devolution of the human species and 'pollution of the gene pool.'

Artificial Reproductive Technologies, organ donation, and genetic interventions additionally stimulated new insights into the definition of what is human. Although medical devices and prosthetics date to the early Egyptian civilization with evidence of dental wire and artificial dentures, the 20th and 21st centuries have witnessed the unprecedented ability of humans to control their own life course, even when severely injured or suffering from chronic illness which would have been fatal only decades earlier. In medical ethics, controversies over expensive medical interventions often arise in arguments concerning distributive justice and just allocation of resources, for example providing the elderly with life-extending technologies in lieu of investments in pediatric health resources (since health resources are always finite).

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TABLE I. TAXONOMY OF MEDICAL ROBOTS

Robot Type	Description and Use
Rehabilitation / Prosthetic Robots	Primarily used for victims of stroke, these machines can be assistive (help to carry out lost functioning), or help in training and therapy to restore lost motor skills. Electronic Exoskeletons may substitute for musculoskeletal movement of the human body.
Patient Support Robots	There are a wide range of patient support robots that can aid in decision-making, mobility, companionship and conversation via intelligent personal assistants that adapt to the patient. Subtypes: Personal Care Robots (PCR), Person Carrier (PCaR), Physical Assistant Robots (PAR), and Mobile Servant Robots (MSR).
Surgical Robots	Surgical robots include computer guided laparoscopes sometimes with sophisticated vision and guidance systems as well as human guided devices such as the Da Vinci Robot that scales down human hand motions to precise movements.
Imaging and Navigation Robots	This class of robots serves as adjunct technologies to surgical robots, and can assist in diagnosis and biopsy.
Decision Making Robots (software)	Clinical Decision Support System (CDSS) software assists in clinical diagnosis at point of care and can be integrated with Electronic Health Records (EHR).
Bionic Robots	Bionic robots integrate electronics with biological structures and processes forming hybrid systems.
Automated Pharmacy Robots	These systems measure and dispense medications and can respond to data from the EHR or adaptive learning software and may be integrated with CDSS.

Steinert has introduced a taxonomy of social robots based on the prevailing modes of ethical discourse in the ethics field. He recognizes five “gravitational centers” towards which recent ethics discussions in robotics have been drawn: “(1) Robots as mere means to achieve a specific goal; (2) the robot as an addressee/recipient of ethical behavior; (3) the robot as a moral agent; (4) the robot as an ethical impact-factor. A fifth dimension is then introduced: The “meta-perspective” invites ethicists and researchers in robotics to be sensitive to how their discipline and thinking is influenced” [2]. The value system of the moral philosopher is relevant in philosophical discussions, particularly the philosopher’s definitions of life and attitude towards technology itself. Those philosophers who take a materialistic view of human life, the idea that we are essentially composed of the same molecular structures as machines, versus thinkers who posit a metaphysical and immaterial human soul or spirit that differentiates sentient beings from mechanical, chemical, and physical processes, will come to different conclusions about the relationship between mankind and robotic machines. This contribution draws on Steinert’s classification in the sections below.

II. ROBOT AUTONOMY

To what extent can and should machines act totally independently of human control? Isaac Asimov formulated his three laws of robotics in response to the fears that autonomous robots could act maliciously or negligently, clearly violating the key Hippocratic injunction in medicine of ‘primum non nocere’ or ‘first, do no harm.’ Asimov’s first law states “a robot may not injure a human being or, through inaction, allow a human being to come to harm” [3]. If medical robots become completely autonomous, a “responsibility gap” could arise in law and ethics. As Villaronga explains: “The responsibility gap theory suggests that, if robots learn as they operate, and the robots themselves can, on the course of operation, change the rules by which they act, then not the humans but the robots should be held responsible for their autonomous decisions” [4]. Clearly then totally autonomous robots would require a new status in society commensurate with human beings, with concomitant rights and responsibilities. Could a human punishment system be adapted to modulate robot behaviour? In the past, humans have formulated moral systems such as ‘might is right’ or Social Darwinism which argued that only the strongest should survive. There are ample reasons to believe that an artificially intelligent machine through learning behavior would adopt such a perspective in ethics. If the machine possesses superior physical strength as well as reasoning power, it may interpret its dominance over human beings as naturally sanctioned by inevitable forces such as evolution. The troubling questions of what kind of consciousness, morality, and intentionally we assign to autonomous machine agents has been discussed in detail by both Dennet and Floridi and Sanders [5] and [6]. Based on Floridi and Sanders’s study, Weber advanced the hypothesis that current medical robots can be “involved in ethically consequential behavior, but cannot be held morally responsible due to their lack of autonomously-directed intentionality… they act as *moral agents* without *moral responsibility*” [7].

III. HAPTIC EXPERIENCE OF MEDICINE, EMPATHY, SURROGATE EMOTIONS

The physiology, evolution, and sociology of touch (haptic science) has been studied intensely since the 1950s and has been clearly implicated in the regulation of social interactions, power structures, physical intimacy, and levels of stress and violence in both humans and other primates. Harry Frederick Harlow’s controversial experiments on touch in Rhesus monkeys determined that infant monkeys preferred to attach themselves to cloth covered wire maternal figures in preference to non-cloth covered wire figures holding food. Researchers concluded that touch was a more important need than food to the infants, who established “contact comfort” with the surrogate. Android machines which will be difficult to distinguish visually and tactilely from humans will soon be available in the near future – warmth, texture, gesture, etc. can now be successfully mimicked.

At this point in personal care robot development, however, patients can usually distinguish mechanical manipulation by a machine from human touch and many may not be psychologically satisfied with non-human interactions. Human emotional responses to machines, may in fact impact their cognitive (logical) responses (i.e. perceived notions of real and metaphorical ‘coldness’ or differences in ‘feel’ may equate to less trust of medical robots and lower willingness to share personal and intimate details and health information with them). These responses, whether logical or not, can subsequently result in a negative provider-patient interaction, and as has already been established in medical education research, negative interactions with healthcare workers or a healthcare system result in negative healthcare outcomes.

Thus the emotional underpinnings of successful doctor-patient relations and communications, such as verbal communication, touch, eye contact, voice tone, may not translate to the man-machine interaction, particularly when the patient is aware that they are not interacting with a human. The potential bias of the patient against a machine as a non-feeling, non-sentient, non-emotional entity could impede such rational processes as resolving medical ethical questions between robot and patient, discussions over choice of competing therapies, and shared decision making. Pessoa, therefore, drawing on growing evidence from the cognitive sciences, argues that emotional and cognitive ability must both be programmed into the next generation of social robots: “cognition and emotion need to be intertwined in the general information-processing architecture ….the contention is that, for the types of intelligent behaviors frequently described as cognitive (e.g., attention, problem solving, planning), the integration of emotion and cognition is necessary. The proposal is based on a growing body of knowledge from brain and behavioral sciences” [8].

IV. Ulterior Motivation, Trust, Data Privacy

Particularly in the case of social robots which interact with the patient, robots will often store Personally Identifiable Information (PII) and Personal Health Information (PHI) which is heavily regulated in North America and Europe. Aggregation of large amounts of PII and PHI on remote centralized cloud servers, which is necessary for smart clients, presents several threats including internal misuse and data breach [9]. Thus data privacy and security are key ethical and legal issues. Also, as with other Internet of Things devices, medical devices connected to the Internet are vulnerable to malicious actors and remote attacks: researchers at the University of Southern Alabama in 2015 were able to “kill” iStan, a wireless patient simulator mannequin, by speeding up its heart pacemaker using brute force and Denial of Service (DoS) attacks [10].

We would reasonably expect as patients that medical robots treat us in the Hippocratic tradition in our best interests and in the medical ethical tradition of Aristotle’s Virtue Ethics, exercising the highest values of the profession (αρετή). However, just like humans, autonomous robots may have other motivations, such as maximizing profit, reducing patient interaction times, minimizing their potential liability, and allocating resources according to their own needs and interests.

Stahl and Coeckelbergh have summarized the primary issue with robots as moral agents: in arguing ethical issues, traditionally philosophers have predicated arguments on rational, intentional actors as moral agents. However, new areas of non-human ethics have arisen, such as animal ethics, and in the field of Ecocriticism and Environmental Ethics some philosophers have ascribed rights and moral status to inanimate objects such as forests and rivers. As Stahl and Coeckelbergh argue: “Robots do not seem to have the capacity of moral reasoning or, more generally, of dealing with ethically problematic situations. Hence when a moral problem arises within the human–robot interaction and within the healthcare situation, there seems to be a problem: the robot is given (more) autonomy, in the sense of doing tasks by itself without human intervention, but does not seem to have the capacity of moral agency: it can do all kinds of things, but unlike humans does not have the capacity to reflect on the ethical quality of what it does. Some philosophers therefore propose to build-in a capacity for ethical reasoning… whereas other philosophers deny that this is possible or think it is insufficient for dealing with complex ethical issues in healthcare” [11].

As mentioned earlier and as Stahl and Coeckelbergh underscore, the philosophical community is deeply divided on the possibility of the moral reasoning power of machines, and some of this controversy rests on the definition of machines and humans themselves, and how they exercise choice – robots’ use of cognitive tools for decision-making are often based on hierarchies, rules, statistical methods, or protocols, even if these algorithms were initially determined from seemingly random or unstructured phenomenal experience gathered from the interactions of the robot with their external environment.

However, MacDorman has provided a possible framework involving Android-human interaction that could lead to the evolution of ethical models in robots mimicking how humans themselves evolve as ethical beings and adopt moral standpoints and create ethical reasoning frameworks – the model depicted in Fig. 1 below, involves hypothesis formation/ verification, and analytical modes and pattern recognition.

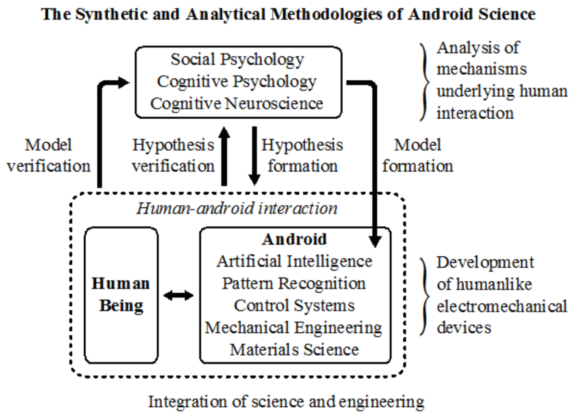

Figure 1. MacDorman’s 2006 model for integrating human-android interaction [12].

V. Social and Economic Dimensions: Worker Displacement, Devolution of Humanity

Since the early 19th century, scientific progress has been almost universally been viewed as positive and beneficial to mankind. Some dissenting voices to scientific Positivism included Marx’s critique of industrialization and capitalism in *Das Kapital* (1867-1883), and the various socialist novelists, playwrights and movie makers who chronicled the negative effects of factory work, alienation, worker exploitation, and placing financial profits above human happiness. Upton Sinclair was one critic whose sensational novel *The Jungle* (1906) analysed dehumanization in the mechanized meat packing industry in the early 20th century. Thus although the development of medical robots may have certain medical benefits, a holistic view of technological progress would take into account larger social issues, such as the potential for increasing unemployment and healthcare worker displacement. If robots completely relieve humans of healthcare duties and responsibilities, including research, what role would humans play in the healthcare workplace, if any? Would humans devolve and lose such motivations as curiosity, or the spirit of inquiry and discovery which drives many scientific discoveries? Humans would most certainly in the above scenario lose the technical facility to design and carry out biological and engineering experimentation. Humans would thus become truly dependent on machines. Also, some recent economic analyses of medical technology have indicated that traditional processes carried out by humans may still be more cost efficient, when taking a global economic view of total and ancillary costs [13] and [14].

VI. Conclusion

This contribution has asked more questions than provided concrete answers to emerging ethical problems arising from the increasing sophistication of medical robots, specifically social and emotion robots, and decision-making agents driven by artificial intelligence. The arrival of entirely autonomous and independent machines will necessitate a rethinking of contemporary human ethics as well as legal and regulatory frameworks, and perhaps of the structure of human societies.

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