

Surgical, Therapeutic, Nursing and Sex Robots in Machine and Information Ethics

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Abstract Machine medical ethics is a novel field of research for ethicists, philosophers, artificial intelligence experts, information scientists, and medical specialists. I identify surgical, therapeutic, nursing and sex robots as the primary types of medical machines in this context. I raise general questions about machine ethics with a view to its development and application, specific questions about medical machine ethics (the term and concept which I prefer), and broad questions spanning multiple non-machine ethics, including information, technology, business and legal ethics, and interrelationships between these diverse ethics and machine medical ethics. Samples of each type of question are provided in my descriptions of surgical, therapeutic, nursing and sex robots. In particular, progress in information and technology ethics is needed in order to solve moral problems involving medical machines, and progress in machine ethics to prevent some of the problems.

1 Introduction

Robots have reached several peaks of attention. They reached the first peak in fiction, in the poems and stories by Homer and Ovid, by Stanislaw Lem and Isaac Asimov, and in movies as different as “Metropolis”, “Star Wars” and “WALL-E”. They reached the next peak in industry, with production machines that assemble other machines. Finally, they reach a peak of attention in everyday life where robots can take all kinds of forms. Some are inconspicuous, as for instance vacuum or mowing robots. Others such as ASIMO and Qrio are conspicuous because they are similar to man (humanoid)—so were Talos, the legendary Cretan guardian, and Pandora, the artificial woman with her box.

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Robots are present in everyday life, and living with them can be different for different people. It can tip to extremes, and the extremes can become everyday routines, for instance for patients. Surgical, therapeutic, nursing and sex Robots are conquering the healthcare systems in households, doctors' practices, and clinical centers. They supplement and complement human workforces and fellow human beings. They can do some things better, some things just as well, and some things worse. Usually they are very expensive, on the other hand they can generate cost savings. Then suddenly they multiply to an extent that makes them a popular topic of mass media.

This article takes the perspective of ethics without prioritizing on robot ethics as one might expect in this context. The issue is scientific ethics, and it is very important that it gains a new self-confidence and makes it to the headlines of newspapers and TV programs. With the combination of robots and ethics, this might well succeed.

In the beginning, the article explains human and machine ethics as well as applied ethics, with special consideration of information ethics, technology ethics, and medical ethics. Then follow questions related to machines as subjects and humans as objects. Not lastly, this shows how to distinguish machine and human ethics (including their specific ethics) from each other. At the end, it evaluates the questions, and as if the future had not been dealt sufficiently before, it takes an outlook into the future.

2 The Machine in Morality

Different ethics are dealing with the machine in morality. For thousands of years, ethics has been human ethics—leaving out the morality of the gods, for instance of the Olympus for once. This means ethics related to humans as subjects and often also humans as objects. Other ethical concepts seem to have occurred only in science fiction and in think tanks. The situation has become more complicated ever since the occurrence of (partly) autonomous systems, since machines—which is exactly what I mean here—decide and act independently of humans. Machine ethics can be seen on the same level as human ethics, therefore it is important to clarify both terms. Within human ethics, several disciplines of applied ethics may feel competent, especially information ethics and technology ethics. Further, the gap between the world of machines and the world of medicine has to be bridged, therefore I have to introduce medical ethics.

2.1 *Human Ethics*

Ethics as science is a discipline of philosophy and morality is its object. Empirical or descriptive ethics describes morality (“Moral” in German [33]) and the

will for moral behavior (“*Moralität*” in German [33]), normative ethics rates it, criticizes it, and where necessary, gives reasons for making changes in behavior. Normative ethics does not finally refer to religious or political authorities or to what is natural, customary, or well-proven [27]. One can also refer to the will for moral behavior using normative ethics, and point out discrepancies between attitudes and behaviors. Metaethics analyses moral terms and propositions from a semantic perspective. Applied ethics is segmented into specific disciplines such as political ethics, medical ethics, business ethics, media ethics and information ethics. Theonomous ethics, referring to the Divine or God, is not part of ethics as a science, nor therefore is theological ethics. The proper subject of morality in human ethics is the human being, and the object is the human being, but in a specific ethics, for instance, an animal ethics, the object might be an animal.

2.2 *Machine Ethics*

According to that, ethics normally relates to the morality of humans, of individuals, and groups, and in a certain way also to the morality of organizations, for instance to the perspective of business ethics or more precisely corporate ethics. Differing from that principle, the issue can also be the morality of machines such as agents, chatbots, robots, UAVs (unmanned aerial vehicles), and unmanned cars, or in other words more or less autonomous programs and systems. Here, one can speak of machine ethics and classify it as information ethics (under computer ethics and network ethics, respectively) or as technology ethics or one can even place it on a par with human ethics [8]. The term “algorithm ethics” is used partly as a rough synonym, and partly in discussion about search engines, dropbox lists and big data; in what follows, I will not refer to this term.

Classification of machine ethics under the umbrella concept “information ethics/technology ethics” means it remains within the ambit of human ethics. This could imply one does not see machines as real subjects of morality, but assigns this privilege to humans alone. In this case, machine morality would be “on loan” from humans and given to autonomous machines with the understanding that it could be withdrawn at any time. Classifying machine ethics as equivalent to human ethics means it is an ethics in its own right, with systems and machines occurring as moral subjects with justification. This is the case when machines assume a life of their own and in certain extremes, independently move away from the ideas and wishes of their human inventors. Maybe this possibility is the source of the idea that morality is not something that lifts humans above other creatures, mechanical or organic.

If one understands machine ethics as an ethics in its own right, one can try to develop new normative models that match machines, models that they can process easily. Just as well one can try to refer to more classic normative concepts from philosophical ethics, and in this vein I think deontological ethics is a suitable candidate for machine morality [31]. A machine can easily process a duty or

a top-down rule. An example: One can teach a machine to tell the truth (which will always be the truth in the situation), or to by-pass animal or human obstacles, or to brake to avoid them. Is a machine able to do more than follow such instructions? Is it able to consider the consequences of its actions, and act responsibly? Is it hence able to be obliged by consequentialist ethics or responsibility ethics? Thus, it seems that classic normative models, such as can be traced back to Aristotle or Immanuel Kant, are generally amenable for machine processing [12].

Robot ethics is a germ cell as well as a specialty of machine ethics [14, 30]. The central ethical issues are whether a robot can be a subject of morality, and how to implement machine morality. This discipline also focuses on mimicry, gesture and natural-language skills, as far as these are embedded in a moral context. If a human being approaches a robot, and the robot makes a face and says, “You are so ugly!”, this takes us right to the heart of design, with one foot already on the field of morality. Thus, one can ask not only about duties, but also about the “rights” of robots. However, machines, being different to animals, are not normally granted rights. Not lastly, one can understand robot ethics in a very different sense; namely, in relation to the development and production as well as the consequences of robot applications. With this view, it can be located under technology ethics and information ethics. It follows that the term “robot ethics” is complex as well as easy to misunderstand. Although this article addresses ethics with a focus on robots, I prefer the terms “machine ethics” and “information ethics” or “technology ethics”, as it concerns machines as subjects on the one hand, and humans as objects on the other, and the mentioned terms are clearer and less amenable to misunderstanding.

2.3 Disciplines of Applied Ethics

2.3.1 Information Ethics and Technology Ethics

The object of information ethics is the morality of those who offer and use information and communication technologies (ICT), application systems and new media [9, 29]. It inquires how these persons, groups and organizations behave in aspects of morality and ethics (empirical or descriptive information ethics) and how they should behave (normative information ethics). Those who do not offer and use ICT and new media but are involved in their production or are affected by their effects are also relevant. So, information ethics focuses on morality in the information society and analyses how its members behave, or should behave, in moral terms. It also analyses the relationship of the information society to itself, to non-technology affine members, and to low tech cultures under ethical aspects. Meta-information ethics analyses moral propositions or statements, starting for instance with the information technological terms, and it locates and compares concepts of information ethics. Computer, network and new media ethics classify

under information ethics. This makes internet ethics a part of it, and machine ethics—as far as the machines are enriched with information technology (IT)—also seems to be close to it. The relationship between machine and information ethics was addressed above.

Technology ethics relates to moral issues of the use of technique and technology [13]. It can focus on the technology of vehicles or arms as well as on nanotechnology. There are manifold relations to science ethics. In the information society, technology ethics is also closely connected to information ethics. Not lastly, it has to cooperate with business ethics, in as far as companies are involved in the development and marketing of technological products, and these are demanded and used by customers. As robots and machines in general are technologies, technology ethics also seems to be very close to robot ethics and machine ethics. What was said in the previous paragraph also applies to the relation to machine ethics, and for robot ethics I refer to the above discussion. The section of robot ethics that analyses the effects of robots on humans is closely connected to technology ethics.

2.3.2 Medical Ethics

The object of medical ethics is the morality in medicine. Empirical medical ethics analyses moral thinking and behavior as related to the treatment of human illness, and the promotion of human health. Normative medical ethics deals “mit Fragen nach dem moralisch Gesollten, Erlaubten und Zulässigen speziell im Umgang mit menschlicher Krankheit und Gesundheit [English translation: “with questions of what is wanted, allowed and permitted morally, especially in terms of human illness and health”]” [34, p. 10]. Furthermore, the handling of animal illness and health can be reflected and transferred to human conditions.

Medical ethics shows increasing overlap with information and technology ethics. Medicine has long used instruments for diagnosis, treatment and surgery, and more recently some of these instruments have become machines, or parts of machines. Some machines are more than instruments, however, as for instance (partly) autonomous robots and information and consulting systems. In machine medical ethics or medical machine ethics, medical ethics now also meets with machine ethics.

3 Machine Medical Ethics Versus Medical Machine Ethics

Machine medical ethics or medical machine ethics defines a special range of medical ethical or machine ethical applications. Machine medical ethics opens a new field to medical ethics. Medical ethics deals in the present context with specific moral questions, related to machines as moral subjects. The question is how

medical ethics copes with this requirement: on the one hand, it has to acquire knowledge about (partly) autonomous machines and their moral skills; on the other, it needs to acknowledge the conventional view of humans as privileged subjects in applied ethics.

Medical machine ethics develops from a machine ethics that structures its object, and finds the health sector as its field of primary application. As moral machines, it mainly identifies robots, but possibly also special information and consulting systems, intelligent houses and other “housing and living machines”. This makes medical machine ethics close to robot ethics in a narrower sense and with relation to medicine, and it searches for other allies. Medical machine ethics is acquainted with non-human subjects of morality.

The situation reminds us of the discussion and development in business ethics. Göbel [22] distinguishes between (1) the application of ethics to economy, (2) the application of economics to morality, and (3) the integration of ethics and economics. Some aspects seem to support letting professional ethicists such as philosophers work on business ethics in the sense of conventional applied ethics. But, economists might be just as prejudiced as theologians who strongly intervene in business ethics. However, the question is whether machine ethics, understood as equivalent to human ethics, or medical ethics as specific ethics, should dominate or initiate. I propose that machine ethics, in close cooperation with medical ethics and medicine, develops a medical machine ethics, and one important argument supporting this was presented in the last paragraph.

At this point, one might ask who machine ethicists really are. Are they professional ethicists, as the name suggests? Or are they a motley crew of ethicists, other philosophers, experts for artificial intelligence, robotic experts, computer scientists, and more recently also business information scientists because of the economic implications? This might come closer to the truth, I suspect, and is supported by a rough analysis of the pertinent literature (e.g., [3, 35]). Another proposal would merit machine ethics to be the object of ethicists, in close cooperation with other disciplines. I presume no one objects to other science disciplines giving essential impulses. All in all, machine ethics is too cross-disciplinary for a field to make a fight for competencies reasonable. There is another aspect: in the present further training market it is easy to certify as an ethicist. Nothing objects to that, and in the end it is the results achieved with correct methodology that count.

Although the discipline of machine medical ethics or medical machine ethics is still very young it already has yielded promising results in theory and practice. The MedEthEx by Susan and Michael Anderson is but one salient example. Wallach and Allen [35] summarize the sense and purpose of the machine: “MedEthEx learns how to weigh duties against each other from the decisions made about specific cases by medical ethics experts when duties conflict.” [35, p. 127] They point out: “The Andersons would not claim that MedEthEx is suitable for autonomous decision making in the clinic, although they do see this kind of software being useful in an advisory role.” [35, p. 128] This role could be used not only by humans, but also by robots, meaning other machines which however would have to face the same ethical challenges as MedEthEx.

4 Robots in Healthcare

Robots have become inevitable in healthcare. A TA-SWISS study published in 2013 under the title “Robotik in Betreuung und Gesundheitsversorgung [Robotics in nursing and healthcare]” represents the opportunities as well as the risks in applied ethics [5]. Indeed, Switzerland is a land of robots: research of universities such as the University of Zurich, ETH Zurich and ETH Lausanne is widely acknowledged, and some Swiss researchers have an international reputation [32]. However, almost no research is devoted to the moral behavior of machines. The US-American study “Healthcare and Medical Robotics” [1] analyses the market for medical robots from 2010 to 2016 and gives an optimistic outlook.¹ By now, the reality of artificial assistants has become so complex it needs systematic analysis.

I propose to classify medical robots in this context in categories of surgical, therapeutic, nursing and sex robots [11]. Obviously, there is overlap between the different fields of operation. Surgery can be a form of therapy, and it is not always possible to segregate therapy and nursing precisely. Not everyone will be convinced that sex robots should be added to this category, but a sex life that fulfills the individual needs surely contributes to health and wellbeing. Probably one can identify additional types now and in future, for instance, tiny diagnostics robots that move through bodies, or medically trained counseling robots, or robots as “avatars” and tools of non-mobile people while controlled by way of brain-computer interfaces (BCIs). Furthermore, certain artificial limbs could be considered robots [6, p. 23].

The term “service robot” requires consideration. One could call all of the aforementioned robots “service robots” to segregate them from industrial robots [20, 21]. Depending on the language, the term “service” might sound strange in certain fields of application. Robots of this type are often described and discussed by the general public, which is not *prima facie* an objection to the use and dissemination in academic language, but against the use and dissemination in everyday language. Surely, it would be desirable for the general public and academic science to agree on a shared terminology.

Decker [20] differentiates between “personal/domestic robots” and “professional service robots”. In the first category, he includes robots for “handicap assistance” (e.g., “robotized wheelchairs”) next to personal assistants, vacuum and pool robots, and in the second category, he lists machines in the field of “medical robotics” (e.g., “diagnostic systems” and “rehabilitation systems”). Of course, there may be robots that can be used in the personal/domestic as well as the professional contexts, and therapy and nursing robots are of that kind.

¹ The company informs on its website: “A new study by ABI Research, ‘Healthcare and Medical Robots’ foresees the global market for medical robotics growing from just under \$790 million in 2011 to nearly \$1.3 billion in 2016, driven largely by sales of advanced surgical robots and related automated radiosurgical systems” [2].

Healthcare robots can be distinguished further by other criteria. Some appear as instruments used in production halls or fitness studios; others look like humans, being more or less humanoid or anthropomorphous. A few of them are in between. A robot like JACO that consists of an arm with a hand with three fingers is like an industrial robot and a living being at the same time. Robot gender is a category based on appearance. Female chatbots, for example, are “fembots”. Some robots can act only, others can mimic and gesture, others can understand human language, and read or write. Other criteria for distinguishing robots in general and more specifically for medical service robots in a wider sense, are developmental level, degree of autonomy, mobility, local and remote control, intelligence, ability to learn, velocity and costs. There are also important differences in quantity and quality of the sensors [26] and media.

Developmental level is a critical factor. Some robots are in productive use, others are prototypes. Some are merely at the level of a draft idea. Truly, machine ethics as a field has not even achieved pubescence. Although it is human to peer into the future, and to ponder what might be, roboticists and machine ethicists should state clearly in their published research what is present and future, what is real and what is mere fantasy.

In what follows, medical robot types are described in surgery, therapy, nursing and sex contexts and related to issues of machine ethics and applied ethics, as framed above. The field of application is briefly outlined before the type is explained, followed by some illustrative examples. At the end of the chapter, I raise some questions which we have to answer if we take machine medical ethics or medical machine ethics seriously. The general questions concern machine ethics in all, partly in relation to the field of application, the special questions relate to medical machine ethics, and finally questions are raised about specific ethics, indicating options for distinguishing the machines listed in this chapter.

4.1 Surgical Robots

Surgery is an intervention by means of instruments and devices on or in the body of a human or animal patient. Its main purpose is therapy, diagnosis or modification, especially modification for cosmetic ends. Usually surgery is done under local anesthesia, or under general anesthesia to avoid pain and unwanted reactions. The person performing the surgery, normally a specialized physician, is the operating surgeon. Surgery is typically performed in hospitals or medical practices.

Surgical robots can be used to carry out specific actions during surgery, or even to conduct an entire surgical process. They are able to make very short and very precise cuts, and to mill and drill with the highest precision. Normally they will be controlled by a physician who is on site, or at another location, or they might function, in very exactly defined limits of time and space, more or less autonomously. The advantages of robot surgeons are that the intervention is gentler and more

agreeable for patients, and physicians are afforded clear views of the body area targeted for surgery [23]. The high cost of robot surgeons, however, is a drawback.

Several prototypes have been developed since the 1990s and launched on the market. The ZEUS Robotic Surgical System, or ZEUS, is already a piece of medical history. ROBODOC (www.robodoc.com) can drill bones for hip joint replacements. The da Vinci Surgical System (www.davincisurgery.com) is popular in clinics for radical prostatectomy and hysterectomy. It is a telerobot and hence only partly autonomous [6, p. 23]. The Amigo Remote Catheter System (www.catheterrobotics.com) is used for cardiac surgery, the CyberKnife Robotic Radiosurgery System (www.cyberknife.com) for cancer therapy, and the Magellan Robotic System (www.hansenmedical.com) for vascular intervention.

In surgical contexts, there are (1) general questions concerning machine ethics, (2) specific questions concerning machine medical ethics, and (3) questions spanning multiple non-machine ethics:

1.

- Should the surgical robot have moral skills, and if so, what skills?
- Should it follow defined duties only (deontological ethics), or should it be able to estimate the consequences of its actions (consequentialist ethics) and weigh pros and cons in decision-making?
- Do other normative models apply, for instance, a materialistic concept?
- How autonomous should it be?

2.

- Should the robot under certain circumstances be able to refuse performing surgery?
- Does it have to consider patient needs and parameters?
- How to handle that the robot normally will not be able to adequately respond to uncertainty and worries? [6, p. 23]
- Is it obliged to express its own concerns and report unforeseen events?
- If it is autonomous, does it need a human surgeon to assist in certain situations?

3.

- Who is responsible if the machine performs poor surgery? [6, p. 24]
- How to handle uncertainty and worries caused by the robot?
- How do the Hippocratic Oath and the Geneva Declaration of the World Medical Association apply?
- Does a robot surgeon support or compete with physicians and their assistants? [6, p. 25]
- Does it interfere with communication between the surgeon, assistants and other medical staff? [18]
- How to rate the circumstance that only certain clinics and medical practices can afford such robots? [18]

These questions might be answered from the perspective of information, technology, medical, occupational and business ethics. Partly, they are related to legal ethics, for instance, with regards to responsibility, liability, and the legal status of robots as “natural persons”. From an ethical perspective, Bekey [6, p. 25] generally determines: “Truly autonomous procedures on the part of a robot surgeon will require a number of safety measures to ensure that patients are not harmed.”

4.2 *Therapeutic Robots*

Therapy means activities for treating injuries and illnesses as well as misalignments. Its objective is to permit or accelerate healing, to eliminate or alleviate symptoms and the recovery or production of normal physical or psychological functioning. There are several options for therapy, for instance surgery, medication, physical therapy, or psychological counseling. In a narrower sense used in everyday language, therapy is something that follows an (often drastic) intervention, such as surgery. In this context, the term of rehabilitation is also relevant.

Therapeutic robots support therapeutic activities, or apply such activities, such as performing exercises with paraplegic patients. They entertain dementia patients, and challenge them with questions and games. Some look like industrial robots, others can mimic, gesture and use language. They can learn and be “intelligent”. Some advantages of therapeutic robots are potential cost-savings and reusability; disadvantages include possible unwanted effects of robot therapy, and poor acceptance by the patients and their family members [17, p. 151 ff.].

There are a large number of products and prototypes. The robotic seal Paro (www.parorobots.com) is very popular. It has been used for therapy for years, in Japan where it was developed, as well as in Europe. It has a high acceptance by patients because its non-humanoid appearance does not raise high expectations, thus avoiding the “uncanny valley effect”. Paro can understand its name, and it remembers how well or badly it was treated, and how often it was petted. It expresses feelings through noise and movements. Keepon (www.mykeepon.com) is a small, yellow robot and also highly popular. It is designed to study and improve social interaction of autistic children. It is available on the mass market, probably because it looks funny, likes to be cuddled and tickled, and knows how to dance.

The general machine ethics questions for therapeutic robots are the same as for surgical robots, but there are different (1) unique machine medical ethics questions and (2) non-machine ethics questions:

1.

- Must therapeutic robots implement certain therapeutic concepts and models?
- Do they have to consider patient needs and parameters?
- How to handle that the robot normally will not be able to adequately respond to uncertainty and worries? [6, p. 23]

- What are the consequences if patients come to depend on the robot? [6, p. 22]
- How should the robot behave in case of conflict, for instance, if several drugs are suitable, or if several patients need therapy? [6, p. 23]
- Should it make it clear to patients that it is no more than a machine?

2.

- Is it relevant to therapy that some robots appear as robotic toys?
- Who (or what) is responsible if the machine performs poor therapy?
- How to deal with uncertainty and worries caused by the robot?
- What if social contact between patients is reduced by the robot? [16]
- How to handle personal data collected and evaluated by the robot?
- Does the robot unburden or compete with therapists and psychologists?
- How to evaluate the fact that only certain people can privately afford therapeutic robots?

A general problem is that therapeutic robots and patients are frequently together on their own, making it difficult to assess whether the therapy works or requires further improvement. It is likely that therapeutic robots will routinely gather and evaluate certain patient data. However, the challenge here is that it is unknown how best to systematically assess such data in order to optimize therapeutic outcomes and that the informational autonomy must be protected.

4.3 Nursing Robots

In nursing care, we distinguish between healthcare and nursing, as well as care for disabled persons and care for older persons. Accordingly, it includes care and services for ill, disabled, old and dying patients by nurses and medical staff, and assistants for disabled or older adults. The central issue is to care for the wellbeing and health, and to avoid illness. The interests of vulnerable patients in need of care should be recognized and taken seriously. Care for animals presents an additional challenge.

Currently, nursing robots either support or replace human nurses. They administer drugs and food to patients, and help them to sit up or lie down. They entertain patients, and they act as auditive and visual interfaces to human nurses. Some have language skills, and can learn. The main advantage of nursing robots is that they are available 24/7, day or night, and with certain limitations also in intermediate phases where care is not necessary and the quality of their service is constant. The main disadvantage, of course, is high costs of such machines and the reduction of interpersonal human contact. Nursing robots require specialization to complete complex nursing tasks, which is a very considerable technical and engineering challenge.

Domestic and nursing robots are represented in trade fairs and conferences. Some are already in productive use. The “nurse’s assistant” HelpMate and the “nurse-bot” Pearl are earlier developments supporting the nursing staff [6, p. 22].

HelpMate transports objects. Pearl supplies useful information and visits patients. JACO (kinovarobotics.com) is a robot with one arm and a hand with three fingers. It can pick and bring objects in its reach, such as from a station at the bed. Care-O-bot, developed by the Fraunhofer Institute for Manufacturing Engineering and Automation IPA (www.care-o-bot.de), can pick and bring even objects from further away. It moves safely among people and through the patient's room. Hospi by Honda communicates between doctors and patients, and can bring sick persons the drugs they need [15]. Cody from the Georgia Institute of Technology can turn and wash bedridden patients autonomously (www.hsi.gatech.edu/hrl/clean-iros10.shtml).

The general machine ethics and unique machine medical ethics questions are the same as for the previously described medical robots, but there are some different specific ethics questions for nursing robots (e.g., Should it be possible to exclude future care by robots in patient declaration of will?). A general challenge facing nursing robotics is whether living permanently in the same household as the patient will adversely affect patient social competence. One talks to the machine, one gets used to it, and fellow human beings might become less important.

4.4 Sex Robots

Robot sex, and sex with or between robots, is a subject in science fiction books, movies and series like “Real Humans”, and, partly visualized through avatars, of computer games. However, it is also considered on the healthcare segment, for instance, as a help for disabled and older adults, and for possible support in therapy. The media is enthusiastic about robotic sex, naturally enough, and there has been some academic discussion about it [19, 36].

Depending on budget and taste, sex robots are available as a handy toy or as big as life. They can help people reach sexual satisfaction through stimulation or penetration. Some have natural language skills, which is advantageous since one should not forget that verbal eroticism is very popular in chats, and phone sex was in high demand for some years. The sexual interactions in Second Life can also serve as a reference. The advantages of sex robots are their constant availability, relatively high hygiene standards if handled properly, and unburdening of human sex workers of both genders. Challenges facing sex robots are limited bandwidth concerning sensory satisfaction of human users and low acceptance and understanding by the general population. In Second Life and in other contexts, the use of child avatars and virtual characters might be a problem.

Fuckzilla, presented on the Arse Elektronika 2007, has a full arsenal of toys and tools, from dildos to a chainsaw decorated with tongues [25]. This model seems to be more of an outlandish object of art than a love-making partner to take seriously. In 2007, a German online-shop offered sex androids [24]. Roxxy (www.truecompanion.com) is a fembot (in the widest meaning of the word) which according to information from the company is able to listen and speak, and can

respond sexually to touch. Several personalities are available, ranging from “Wild Wendy” to “Frigid Farrah”. The male equivalent is called Rocky. Both are available through the website of the provider.

Again, the general machine ethics questions are the same as for the previously described medical robots, but there are different (1) unique machine medical ethics questions and (2) non-machine ethics questions for sex robots:

1.

- Should a robot become sexually active on its own, and entice the partner to have sex?
- Should it be able under certain circumstances to refuse performing sexual acts?
- Should it reiterate to the partner that it is no more than a machine?
- Should its design fulfill moral criteria (e.g., prohibition of child-like sex robots, except in case of combating pedophilic crime [4])?
- Should there be novelty options for stimulation and seduction, or should it follow human role models?

2.

- How should the robot collect and evaluate patient data to better satisfy its partner’s sexual needs?
- Who is liable for injuries or contamination caused by sex robots?
- How should uncertainty and shame in patients caused by sex with robots be ethically assessed?
- Should sex robots completely replace human sexual partners for certain patients?
- Does robot sex promote the idea that a sexual partner must be available at all times?
- Should children and underage teenagers be permitted to have access to sex robots for sexual or non-sexual purposes?

The use of sex robots in medicine is a sensitive ethical question. Humans who are sexually substituted by a robot might feel rejected by their partner and carer and patients who choose to have sex with a robot for having no other choice for sexual satisfaction might suffer for lack of human-human sex. Patients who cannot afford a robot might feel disadvantaged. For some adults, sex with robots might be on the same level as sex with animals. For others, it may enrich life and contribute to good health.

4.5 The Robot in the Morality of Medicine

Although asking questions from the perspective of machine ethics is easy, answering those same questions can be very difficult, especially on a case to case basis, and engineering moral medical machines is far from trivial. The large number of questions posed in this section for surgical, therapeutic, nursing and sex robots

seems to indicate that complexity in moral machines is the main challenge [10]. In other words: if surgical, therapeutic, nursing and sex robots are furnished with moral skills, one would expect them to flexibly make correct decisions and perform actions on very different levels and in very different situations. Implementing very simple moral machines—in many cases the right choice—might therefore cause or enhance the uncanny valley effect here. At the same time, we note that redundancies occur in general and that some solutions to the questions asked above probably might be transferred to different types of robots.

Asking questions of applied ethics is also easier than providing correct answers, of course, and in some cases it might be difficult to clearly classify moral machines as falling under a certain ethics. For instance, the autonomy of patients, an enduring topic of medical ethics, in some cases turns into informational autonomy, and thus concerns information ethics. Sexual self-determination as considered under sexual ethics also has to be reviewed with regards to sexual intervention, collection and evaluation by machines. The right of satisfactory work concerns occupational ethics, and can also be discussed from the perspective of information and technology ethics, as the use of information and communication technologies and application systems frequently serves for improving processes and making work easier.

Most aspects of applied ethics might be traced back to information (and technology) ethics because information ethics can be located in the center of applied ethics [7]. If information and communication technologies as well as application systems diffuse into all areas of society and business, this will influence specific ethics. Thus, these ethics will likely draw on information ethics for further ethical guidance.

Anyway the compilation provides a better view of what machine ethics is in a narrower sense, and what counts as applied ethics related to humans. Machine ethics inquires from the perspective of machines, focusing on machines as subjects. Human ethics assumes humans to be subjects as well as objects. It also provides a better understanding of what might be more general questions relating to machine ethics and what might be more specific questions, relating to medical machine ethics or machine medical ethics.

Asking questions, even if not supplying the answers, can lead to knowledge and to a deeper, more structured and systematic understanding. More theory and data are needed in the context of machine medical ethics, as well their ongoing synthesis and eventual symbiosis. Neighboring disciplines such as health technology assessment [28, p. 199] need to be recruited to fortify machine medical ethics, and it will be necessary to interview affected patients and professional staff.

5 Conclusions and Outlook

Machine medical ethics or medical machine ethics is new territory, a novel field of work for ethicists, philosophers, artificial intelligence experts, information scientists, and medical specialists. Surgical, therapeutic, nursing and sex robots are the primary types of medical machines and objects of further analysis as the field

grows. In relation to their development and application, it is possible to ask questions of machine ethics as well as specific ethics. I have reasoned that information and technology ethics in particular are critical to solve ethical problems involving medical machines. Machine ethics might help avoid such problems. If a medical machine is moral, it acts (in the best case) to respect and adequately care for its patients, so that they can lead a good life and maintain personal autonomy. Their acting morally of course could in certain cases also lead to impairing the lives of people. If a machine again and again emphasizes that it is no more than a machine, this might be transparent and honest, but it might also cause uncertainty and frustration. The assessment of uncertainty caused by a robot is a challenge to solve.

Currently, it is sheer guesswork to ponder the domains of applied ethics machine ethics will need to cooperate or merge with. Animal ethics is one candidate. While machine ethics focuses on humans as moral objects, animals are also affected by machine decisions and actions, for example if medical machines operate in households. Military ethics is another potential field of cooperation, despite public unease about it, since there is strong technological overlap between medical machines, military UAVs and fight robots. Religiously motivated objections against moral machines will demand a response from machine ethicists, likely in the form of scientific arguments and data. Considerations such as those raised in this chapter do not mean that machine ethics should be viewed uncritically or blindly. However, I believe that it will be not less than a touchstone of future ethics.

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