

Preface

Machines are occupying increasingly visible roles in human medical care. In hospitals, private clinics, care residences, and private homes, machines are interacting in close proximity with many people, sometimes the most vulnerable members of the human population. Medical machines are undertaking tasks that require interactive and emotional sensitivity, practical knowledge of a range of rules of professional conduct, and general ethical insight, autonomy, and responsibility. They will be working with patients who are in fragile states of health, or who have physical or cognitive disabilities of various kinds, who are very young or very old. The medical profession has well-defined codes of conduct for interacting with patients, in relation to minimizing harm, responsible and safe action, privacy, informed consent, and regard for personal dignity.

Although there is general agreement in the field of machine ethics that medical machines ought to be ethical, many important questions remain. What ethical theory or theories should constrain medical machine conduct? Is theory even necessary? What implementation and design features are required in medical machines? In what specific situations will it be necessary for machines to share praise or blame with humans for the ethical consequences of their decisions and actions? Are there medical decisions for which machine support is necessary? These questions are truly twenty-first century challenges, and for the first time are addressed in detail in this edited collection.

The collection is logically organized in two parts. The essays in Part I address foundational questions concerning machine ethics and machine medical ethics (“[An Overview of Machine Medical Ethics](#)”–“[Moral Ecology Approaches to Machine Ethics](#)”). Part II focuses on contemporary challenges in machine medical ethics, and include three sections: Justice, Rights, and the Law (“[Opportunity Costs: Scarcity and Complex Medical Machines](#)”–“[Machine Medical Ethics and Robot Law: Legal Necessity or Science Fiction?](#)”), Decision-Making, Responsibility, and Care (“[Having the Final Say: Machine Support of Ethical Decisions of Doctors](#)”–“[Machine Medical Ethics: When a Human Is Delusive but the Machine Has Its Wits About Him](#)”), and Technologies and Models (“[ELIZA Fifty Years Later: An Automatic Therapist Using Bottom-Up and Top-Down](#)

Approaches”—“Ethical and Technical Aspects of Emotions to Create Empathy in Medical Machines”). The collection Epilogue is an ethical dialog between a researcher and a visual artist on machine esthetic understanding.

In “An Overview of Machine Medical Ethics”, Tatjana Kochetkova suggests machine roles in medicine be limited to medical cases for which professional codes of medical conduct already exist. In such “consensus cases,” machine algorithms in operant medical machines should be either top-down, bottom-up, or mixed (top-down-bottom-up). Kochetkova cautiously reasons that it is premature to accord medical machines full ethical status. Instead, prudence suggests they be designed as explicit, but not full, ethical agents by humans.

Oliver Bendel (“Surgical, Therapeutic, Nursing and Sex Robots in Machine and Information Ethics”) attempts to shake loose the nature of machine medical ethics by classifying medical machines according to context (surgery, therapy, nursing, and sex), function, and stage of development. Bendel ponders the sub-field of machine medical ethics in relation to its parent disciplines machine ethics and applied ethics, and asks whether machine medical ethics can function independently of these fields. Bendel argues that, in the best ethical case, a medical machine ought to interact with humans in order to respect and preserve their autonomy.

Mark Coecklebergh (“Good Healthcare Is in the “How”: The Quality of Care, The Role of Machines, and the Need for New Skills”) investigates whether machines threaten or enhance good health care. He argues that “good health care” relies on expert know-how and skills that enable caregivers to carefully engage with patients. Evaluating the introduction of new technologies such as robots or expert medical machines then requires us to ask how the technologies impact on the “know-how” expertise of caregivers, and whether they encourage a less careful way of doing things. Ultimately, Coecklebergh thinks machines require new skills to handle the technology but also new know-how to handle people: knowing how to be careful and caring with the technology.

In “Implementation Fundamentals for Ethical Medical Agents”, Mark R. Waser identifies some broad guidelines for the implementation of ethics in medical machines while acknowledging current machine limitations. All ethical machines need top-down medical decision-making rules and bottom-up methods to collect medical data, information, and knowledge as input to those rules, codified methods to determine the source, quality and accuracy of that input, and methods to recognize medical situations beyond machine expertise and which require specialist human intervention. Waser thinks correct codification and documentation of the processes by which each medical decision is reached will prove to be more important than the individual decisions themselves.

In “Towards a Principle-Based Healthcare Agent”, Susan Leigh Anderson and Michael Anderson present a top-down method for discovering the ethically relevant features of possible actions that could be used by a machine as *prima facie* duties to either maximize or minimize those features, as well as decision principles that should be used to influence its behavior. This deontic approach is challenged by Gary Comstock and Joshua Lucas in “Do Machines Have *Prima Facie* Duties?”

Among several arguments Comstock and Lucas present against the Andersons and their *prima facie* method, they argue that such duties do not uniquely simulate the complexities of ethical decision-making. To substantiate this claim, Comstock and Lucas propose an act-utilitarian alternative, they call Satisficing Hedonistic Act Utilitarianism (SHAU). They show that SHAU can engage in ethical decision-making just as sophisticated as *prima facie* based ethical deliberation, and can produce the same verdict as a *prima facie* duty-based ethic in the medical case investigated by the Andersons.

In contrast to the approach taken in the preceding chapters, the next three chapters argue against the idea of a single theoretical machine ethic and for the idea that hybrid top-down-bottom-up approaches offer a more promising ethical line (“[A Hybrid Bottom-Up and Top-Down Approach to Machine Medical Ethics: Theory and Data](#)” and “[Moral Ecology Approaches to Machine Ethics](#)”). Simon Peter van Rysewyk and Matthijs Pontier (“[A Hybrid Bottom-Up and Top-Down Approach to Machine Medical Ethics: Theory and Data](#)”) describe an experiment in which a machine (Silicon Coppélia) run on a hybrid ethic combining utilitarianism, deontology, and case-based reasoning matches in its own actions, the respective acts of human medical professionals in six clinical simulations. Christopher Charles Santos-Lang (“[Moral Ecology Approaches to Machine Ethics](#)”) makes an interesting point that the brains of human beings are “hybrids individually,” by which he means that living brains can adapt our deliberations and judgments to present circumstances in contrast to ecosystem approaches to ethics, which promote hybridization across, rather than within, individuals. Santos-Lang urges, we design and build diverse teams of machines to simulate the best human teams, instead of mass-producing identical machines to simulate the best individual human.

Adam Henschke begins Part II Contemporary Issues in Machine Medical Ethics (Responsibility, Decision-Making and Care) (“[Opportunity Costs: Scarcity and Complex Medical Machines](#)”). Future medical machines that prioritize health care only for a minority of patients to the disadvantage of a majority is ethically unjustified, according to Henschke, especially when resources are scarce. Instead, in a depressed global economy, optimizing health care outcomes requires funding increases for existing health care resources, such as nurses, nursing homes, and family that provide care to their loved ones, rather than mass-producing expensive medical machines that may ultimately serve only the very rich.

In “[The Rights of Machines: Caring for Robotic Care-Givers](#)” entitled, “Rights for Robots?—Caring for Robotic Care-Givers,” David J. Gunkel ponders the question of “machine rights” for health care robots. Gunkel identifies two “machine rights” options: health care robots are nothing more than instrumental tools and accordingly deserve no legal rights; health care robots are valued domestic companions and deserve at least some legal protections. Since each option turns out to have problems, Gunkel urges that the question of “machine rights” be taken more seriously by society.

Are medical machines liable for their actions and mistakes, as are “natural humans”? Addressing this question in “[Machine Medical Ethics and Robot Law:](#)

[Legal Necessity or Science Fiction?](#)”, Rob van den Hoven van Genderen predicts that new legal amendments will enter existing law to represent intelligent machines but only on behalf of a real legal actor, a natural human being. Since machines are best viewed as our assistants, workers or servants, they do not qualify as natural persons, and ought never to have full human rights and obligations. According to van den Hoven van Genderen, the legal system is under human control, and cannot ever be shared with machines.

Beginning the next section in Part III, Decision-Making, Responsibility, and Care, Julia Inthorn, Rudolf Seising, and Marco E. Tabacchi propose that Serious Games machines can share ethical responsibility with human health care professionals in solving medical dilemmas ([“Having the Final Say: Machine Support of Ethical Decisions of Doctors”](#)). The authors show that Serious Games improve upon current machines in clinical decision-making because they can integrate both a short and long perspective and enable learning with regard to bottom-up decision processes as well as top-down rules and maxims. Though there is a reluctance to use machine support in medicine, the possibilities of experiential learning ought to be considered an important aspect of behavioral change that could be used to improve ethical decision-making in medicine. The authors also provide an informative historical overview of decision support systems in medicine.

What are the prospects of “robotic-assisted dying” in medical contexts? Ryan Tonkens ([“Ethics of Robotic Assisted Dying”](#)) proposes that if we develop robots to serve as human caregivers in medical contexts, and given that assistance in dying is sometimes an important aspect of geriatric care, it is ethical for such robots to facilitate and assist in the dying of those patients at the eligible patient’s sound request. A major benefit of robotic-assisted dying is that the robot would always assist those consenting patients that are genuinely eligible, and thus such patients would not be at the mercy of a willing physician clause in order to have some control over the timing and manner of their death. At the same time, specialist humans must remain involved in establishing strict regulations and safety protocols concerning end-of-life situations and be present in the event of machine malfunction.

According to Blay Whitby ([“Automating Medicine the Ethical Way”](#)), unreliable technology and human errors in Information Technology (IT) resulting from poor user interfaces are two outstanding ethical problems. Whitby calls for improved ethical awareness and professionalism in IT workers in order to achieve ethically acceptable medical machines. Lessons from the aviation industry suggest that issues of acceptance and resistance by professionals can be successfully managed only if they are fully engaged in the operational and procedural changes at all stages. Negotiation over procedures and responsibility for errors in aviation is complex and informative for other fields, including machine ethics.

In [“Machine Medical Ethics: When a Human Is Delusive but the Machine Has Its Wits About Him”](#), Johan F. Hoorn imagines an advanced dementia patient under the care of a health care robot and asks: “Should the robot comply with the demand of human autonomy and obey every patient command?” To help answer this question, Hoorn offers a responsibility self-test for machine or human that differently prioritizes top-down maxims of autonomy, nonmaleficence, beneficence,

and justice. The self-test comes in seven steps, ranging from “I do something” (to act, with or without self-agency), to “My “higher” cognitive functions are supposed to control my “lower” functions but failed or succeeded” (to act, with or without self-control).

In “[ELIZA Fifty Years Later: An Automatic Therapist Using Bottom-Up and Top-Down Approaches](#)”, Rafal Rzepka and Kenji Araki present a machine therapist capable of analyzing thousands of patients’ cases implemented in an algorithm for generating empathic machine reactions based on emotional and social consequences. Modules and lexicons of phrases based on these theories enable a medical machine to empathically sense how patients typically feel when certain events happen, and what could happen before and after actions. The authors suggest that this bottom-up method be complemented by a top-down utility calculation to ensure the best outcome for a particular human user.

Neuromachines capable of measuring brain function and to iteratively guide output will be a major development in neuromodulation technology. According to Eran Klein, the use of closed-loop technologies in particular will entail ethical changes in clinical practices (“[Models of the Patient-Machine-Clinician Relationship in Closed-Loop Machine Neuromodulation](#)”). Klein thinks current ethical models of the clinical relationship are only suited to certain forms of neuromodulation, but new models ought to be more comprehensive as new neuromodulatory technologies emerge. Klein assesses design, customer service, and quality monitoring models as candidates for a new ethic and urges that any successful theoretical approach ought to incorporate Aristotelian concepts of friendship.

Steve Torrance and Ron Chrisley (“[Modelling Consciousness-Dependent Expertise in Machine Medical Moral Agents](#)”) suggest that a reasonable design constraint for an ethical medical machine is for it to at least model, if not reproduce, relevant aspects of consciousness. Consciousness has a key role in the expertise of human medical agents, including autonomous judging of options in diagnosis, planning treatment, use of imaginative creativity to generate courses of action, sensorimotor flexibility and sensitivity, and empathetic and ethically appropriate responsiveness.

An emerging application of affective systems is in support of psychiatric diagnosis and therapy. As affective systems in this application, medical machines must be able to control persuasive dialogs in order to obtain relevant patient data, despite less than optimal circumstances. Kim Hartman, Ingo Siegert, and Dmytro Prylipko address this challenge by examining the validity, reliability, and impacts of current techniques (e.g., word lists) used to determine the emotional states of speakers from speech (“[Emotion and Disposition Detection in Medical Machines: Chances and Challenges](#)”). They discuss underlying technical and psychological models and examine results of recent machine assessment of emotional states obtained through dialogs.

Medical machines are affective systems because they can detect, assess, and adapt to emotional state changes in humans. David Casacuberta and Jordi Vallverdú (“[Ethical and Technical Aspects of Emotions to Create Empathy in Medical Machines](#)”) argue that empathy is the key emotion in health care and that machines need to be able to detect and mimic it in humans. They reinforce

modeling of cultural, cognitive, and technical aspects in health care robots in order to approximate empathic bonds between machine and human. The emotional bonds between human and machines are not only the result of human-like communication protocols but also the outcome of a global trust process in which emotions are cocreated between machine and human.

In Epilogue, Dutch visual artist Janneke van Leeuwan and Simon van Rysewyk discuss whether intelligent machines can appreciate esthetic representations as a simulacrum of human esthetic understanding. The dialog is illustrated by selections from van Leeuwen's thoughtful photographic work, "Mind Models."

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