

Ethical and social aspects of robots

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Abstract: Robotics is a very fast growing field especially in the last years and is a discipline based on: mechanics, physics/mathematics, control engineering, electr(on)ics, computer science. Therefore robots are frequently used as examples for Mechatronic Systems.

Robotics unifies two cultures: Science and humanities. The effort to design roboethics should make the unity of these two cultures a primary assumption. This means that experts shall view Robotics as a whole - in spite of the current early stage which recalls a melting pot.

Some decades ago social aspects of robotics were discussed. Because of the results and the rapid development of this field ethical issues became more and more important. Therefore the term roboethics was introduced in the literature. The main goal of this contribution is to present and discuss this subject, probably at the first time, from the viewpoint of robotics.

First an overview from a practical, robotics viewpoint will be given. Then a short presentation of currently and in the future available robots and some ideas about the ethical problems are discussed. Special emphasis is on the ethical behavior of the system “human-robot” and “End of Life – EoL” management.

Keywords: Robots, Ethics, Social Aspects, System “Human-Robot”, EoL of robots

1. INTRODUCTION

Fig. 1 shows an overview on currently or in the future available robots. “Unintelligent”, stationary industrial robots are used mostly in production systems equipped with NC (numerical controlled), machines as well as in CIM (computer integrated) - or imms (intelligent manufacturing) - systems. Currently there are worldwide approximately 1.2 millions working in industry. With a 7th and 8th axis they can be limited movable to extend the working space. They are nowadays equipped with simple external sensors for “intelligent” operations e.g. assembly and disassembly, fuelling cars... and are called “intelligent” robots .

Mobile robots could be divided in three categories. “classic” mobile robots are partially intelligent mobile platforms. As “Autonomous Guided Vehicles – AGV’s “ they are available since some years in industry and equipped with additional external sensors (Intelligent Autonomous Guided Vehicles – Intelligent AGV’s) covering a broad application field. Movement possibilities are wheels, chains..... . Intelligent industrial and mobile robots are used for service tasks – “service robots”.

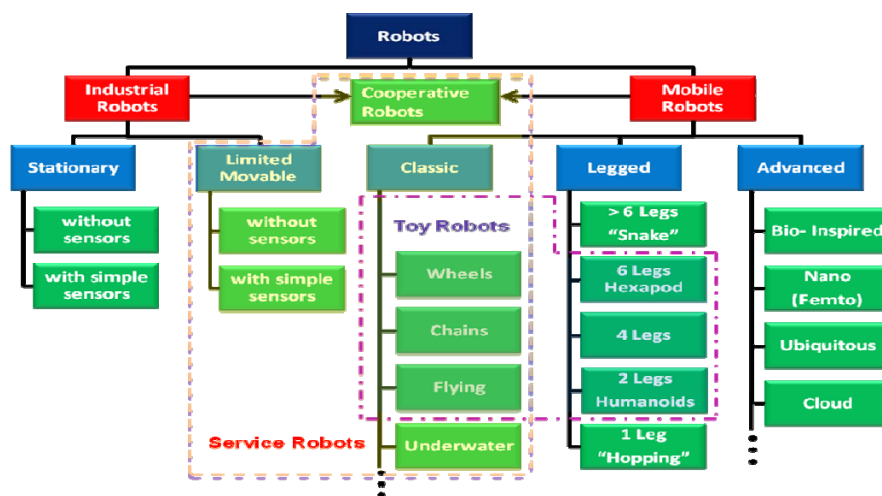


Fig 1 Overview on robots (Kopacek, 2013)

“Advanced” mobile robots are currently in development and exist mostly as prototypes. Some of them will be discussed later.

Walking machines or mechanisms are well known since some decades. Usually they have more than 6 (snake), 4 (multi-legged) to 6 (hexapod), 2 (biped) or one leg (hopping). Walking on two legs is from the view point of control engineering a complex stability problem. Biped walking machines equipped with external sensors are the basis for “humanoid” robots. Some prototypes of such robots are available today.

One of the current trends in robotics is cooperation. Industrial robots are connected by their controllers for synchronisation or controlled by one controller. Latest developments deal with a modularization of the robots as well as the control system.

Mobile platforms with external sensors are available since some years and cover a broad field of new applications. They are the basis of mobile robot platforms. On such platforms various devices, like arms, grippers, transportation equipment, etc., can be attached. Communication between the „on-board PC“ and the „supervisory PC“ is carried out by WLAN or bus systems like CAN - communication with the environment can be accomplished by voice,.....

Possible applications including tele-operation or semi-autonomous operation of robot platforms in various scenarios could be: Factory automation; operation in hazardous environments, planetary and space exploration, deep-sea surveying and prospecting, services....

„Service robots“ are mobile robots adapted for service tasks: For personal use - e.g. cleaning robots, lawnmowers, for healthcare e.g. assistance for handicapped, for leisure and hobby, e.g. game playing, sports (soccer,...).

Biped walking robots are much more flexible than robots with other movement possibilities. The main advantage of legged robots is the ability to move in a rough terrain without restrictions like wheeled and chained robots. Legged robots can work in environments which were until now reserved only for humans. Especially fixed and moved obstacles can be surmounted by legged robots. In addition to walking such robot could realize other movements like climbing, jumping... Intelligent robots – especially intelligent, mobile platforms and humanoid robots are able to work together on a common task in a cooperative way (Kopacek, 2012).

2. ROBOETHICS - FIRST IDEAS

Usually as the roots of Roboethics are the Isaac Asimov's 3 Laws of Robotics:

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 orders given 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 law.

Asimov added the *Fourth Law (Law Zero)*: No robot may harm humanity or, through inaction, allow humanity to come to harm.

These laws are very simple, but Asimov shows in some of his short stories, which conflicts and contradictions would result in practice. A conflict results e.g. obviously from the fact that such robots could hardly be used for martial purposes. The military has naturally a very large interest in intelligent machines and promotes their development very actively.

How one can deal with the fact that a robot will have some times incomplete information. A human could say to a robot, to give poison in a glass of water. To another robot you say the he should serve the glass to a special human. None of the two robots notices that he offends against the 1st law. Incomplete information can evoke fatal errors (Veruggio, 2009).

3. ROBOETHICS

Robotics is a discipline based on: mechanics, physics/mathematics, automation and control, electronics, computer science, cybernetics, artificial intelligence... Therefore robots are frequently used as examples for Mechatronic Systems. Robotics unifies two cultures: Science and Humanities.

The effort to define roboethics should make the unity of these two cultures a primary assumption. This means that experts shall view Robotics as a whole - in spite of the current early stage which recalls a melting pot.

So they can achieve the vision of the robotics future. Robotics scientists, researchers, and the general public have about robots different evaluations:

- Robots are nothing but machines
- Robots have ethical dimensions
- Robots could be moral agents
- Robots are an evolution of a new specie

In particular, we mention the following main fields are involved in roboethics: From the technical side: Robotics; computer science; artificial intelligence and from the nontechnical side: Philosophy; ethics; theology; biology/physiology; neurosciences; law.....

From the viewpoint of robotics the currently used definition (Veruggio, 2005) should be adapted to : “Roboethics is an applied ethics whose objective is to

develop scientific/cultural/technical tools that can be shared by different social and technological groups and believes. These tools aim to promote and encourage the development of robotics including the latest trends for the advancement of human society and individuals, and to help preventing its misuse against humankind.

Questions arise around the shape of the humanoids. Is it right that robot can exhibit a personality? Is it right that robot can express emotion? The concern expressed by psychologist is that, well before evolving to become conscious agents, humanoids can be an extraordinary tool used to control human beings.

Three main ethical positions emerged from the robotics community:

- Not interested in ethics
- Interested in short-term ethical questions
- Interested in long-term ethical concerns

Not the knife is responsible, if one is stabbed, but the actor. There is the temptation, the industry, to attribute military weapons or the technology at all a partial responsibility at the self endangerment of humans. But these accusations do not withstand an examination.

For example an artificial intelligent system a humanoid robot, who has to know, what he has to do in a special situation. From the viewpoint of roboethics the robot must know what to do and to know what not to do. Therefore a robot must act ethically.

He can do this, whom he uses activities, which lead to his goal and which have more advantage than disadvantage for others. What for a robot is applicable, is just as applicable for a human nature. Based on well defined terms, it is possible to provide a scientific ethics and an experimental ethics and use with robots and humans.

Everything that is useful can be abused. The moral responsibility is alone with humans. At the first sight it looks like that someone has to judge also of the robots in the same way.

4. BENEFITS, PROBLEMS, RECOMMENDATIONS EXAMPLES

In the following selected examples for robots (Tab.1) and their applications (Tab.2) will be given concerning ethical issues including latest developments according to Fig.1

Table 1 Examples of robots (adapted from Veruggio, 2005)

Robots		Benefits (examples)	Problems	Ethic Recommendations	
Industrial	stationary	Increase productivity, speed, endurance	Loss of workplaces	Education Programs to create new skills	
	movable	Further increasing of the productivity	Loss of "low tech" workplaces	Increase the "Job satisfaction" by the creation of new "high tech" workplaces by education.	
Mobile Robots	Classic	Increased safety and security	Safety, security, privacy	Update safety and security standards	
	Legged		Much more flexible on workplaces.	Create new safety and security standards	
		Humanoid	For complex tasks; increase the quality of human life (service, entertainment)	User friendly Human Machine Interfaces (HMI)	Safety. Systems for the control of robots autonomy. Improve the education on human- machine interaction and cooperation.
	Advanced	Bioinspired	Open the doors to new applications	Psychological problems, because they are looking like insects.	Create another outfit. Improve the education
		Nano (Femto, Ato)	Application in very narrow environment	Visibility No long term experiences	Make sure that they not are used for unethical and dangerous tasks e.g. transport of bacteria.
		Ubiquitous	Increasing support of humans.	Operation by partially educated people	Educate the operators (users) – solve privacy problems
Cloud		Increased efficiency in performing complex tasks	Dependability of primary services on complex systems	Update international fault tolerance standards to take into account cross-effect complexity and IT security.	

Tab 2 Selected applications

Applications	Benefits (examples)	Problems	Ethic Recommendations
Exploring Robots	Robots could be employed in dangerous operations	Threat to all the other forms of live on the planet	Environmental organizations should promote researches on the impact of the new robotic technologies on nature
Health Care and Life Quality	Minimally invasive surgery reduces patient recovery time	Breakdown of surgical robot systems can cause potentially fatal problems	Improve the TQM standards including ethics.
Service Robots	Increasing the quality of human life.	Psychological problems; Loss of privacy.	Make the robots more “human friendly”. The robot have to be a “friend”.
Toy Robots (Edutainment)	Robot toys can become kids’ companions, e.g. “friend”, “brother” ..;	problems related to intimacy.	Educational systems should incorporate this type of robots in their programs. Make sure that there are real human friends.

In addition to chapter 2 Service Robots are robots of several shapes and sizes and support and back up human operators. These robots can guarantee a better quality of life, providing that designers guarantee safety and security.

Humanoid robots realize the old dream of humans and are able to assist them. From the viewpoint of ethics they support a lot of activities in order to increase the human quality of life.

Intelligent machines can assist humans to perform very difficult tasks, and behave like true and reliable companions. In many ways and are or will be connected to the internet. This yields to the remote human-robot interaction for tele-operation and tele-presence. This and will permit robot-robot interaction for data-sharing and cooperative working and learning and is a pre-stage of cloud robots.

From a social and psychological standpoint, overuse could lead to technology addiction or invasion of privacy. Humans in robotized environments could face psychological problems.

Many applications of mobile robots are to explore, develop, secure, and feed our world and worlds beyond land e.g. demining (Kopacek et.al., 2012), sea e.g. offshore, air (e.g. UAV) or space e.g. space exploration (Kopacek, 2005).

Robotic systems for health care - medical robots have made their way into the operating room. Biomechatronic human prostheses for locomotion, manipulation, vision, sensing, and other functions are still in use e.g. robotic tele-surgical workstations, robotic systems for diagnosis, robots for therapy, haptic interfaces for surgery/physiotherapy training, artificial limbs (legs, arms), internal organs (heart, kidney), senses (eye, ears, etc.), exoskeletons,..... From the social and ethical standpoint, this is one of the fields in robotics that suffers from the most difficult safety and ethical problems e.g. a robot can be only serve as an assistant of a human surgeon but it will never replace the surgeon.

Lifestyle of young people has changed. Robotics is a very good tool to teach technology while, at the same time, always remaining very tightly anchored to reality. Robots will enable us to build real environments. A very good example for *Edutainment* (Education by Entertainment) are robot competitions e.g. robot soccer.

The fascinating idea of using small robot cubicles to play soccer was born just a decade ago. Robot soccer (Fig. 2) was introduced to develop intelligent cooperative multi-robot (agents) systems (MAS) and to bring young generation the difficult scientific and engineering subjects easy in the way of playing. From the scientific viewpoint the soccer robot is an intelligent autonomous agent which carries out tasks with other agents in a cooperative, coordinated, and communicative way. It is also a good tool for spending leisure time and for education (Kopacek, 2009).

From the viewpoint of ethics robot soccer is an excellent example for “ethical programming”. The robots of both teams have to be programmed to act ethical – hard and fair - like in real soccer.



Fig.2 Robot soccer (Kopacek, 2009)

4. SCENARIOS OF THE FUTURE

There are numerous possibilities to use robots, where it could become unpleasant for humans. In addition, they can fulfill everyday tasks. This possibility causes many human concerns and fears. One example for a personal robot is Archie (Fig.3) which is in development (Baltes et.al, 2011).

The goal is to build up a cost oriented humanoid robot supporting humans in everyday life. Therefore Archie has the size of an European teenager and has a head, a torso, two arms, two hands and two legs. The robot should be able to walk in an unknown environment, to do some work and to express feelings depending on the situative context. The human capability is not a simple movement and this is the reason why Archie is a good test object for future ethical programming.

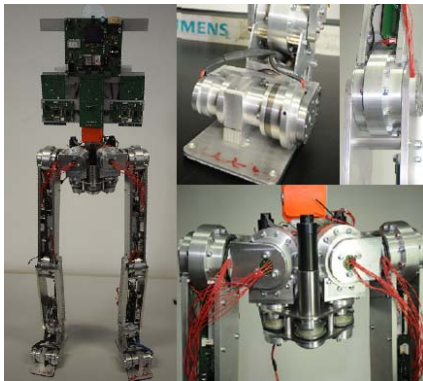


Fig.3 Archie (Baltes et.al, 2011)

5. ROBOTS AND HUMANS

All the different types of robots mentioned before get more and more “intelligent”. They will be adaptive with self-learning functions. The old question “When will be a robot more intelligent than a human?” can only be answered from a personal view point. My answer is “never”.

Currently the ethical behavior of a robot is determined by the software. The features of the software depend directly from the programmers. That means roboethics is closely connected to the ethical behavior of the software developer. If a robot is good or evil depends mostly from the software or from the ethical behavior of a human.

It is almost inevitable that human designers are inclined to replicate their own conception of intelligence in the intelligence of robots. In turn, the former gets wired into the control algorithm of the robots. Robotic intelligence is a learned intelligence, fed by the world models uploaded by the designers. It is a self-developed intelligence, evolved through the experience which robots have gained through the learned effects of their actions. Robot intelligence also includes the ability to evaluate and attribute a judgment to the actions carried out by robots.

From the viewpoint of Systems Engineering the system “Human-Robot cooperation” can be modeled as a dynamic system. This approach goes back to the early nineties (Kopacek et.al., 1990). It can be seen as a stability problem and if the mathematical model of the human and the robot is known the classical stability criteria could be used. For ethics the static approach seems to be sufficient.

Therefore as a first trial the following codes for the ethical behavior level of a robot (R) and a human (H) : high (+), medium (0) and low (-) are used.

With these codes the combinations of Tab.3 are possible

Table 3 System “Human – Robot cooperation”

R\H	H+	H0	H-
R+	+\\+	+\\0	+\\-
R0	0\\+	0\\0	0\\-
R-	-\\+	-\\0	-\\-

If for example a ethical human is confronted with an ethical robot (+\\+) this system will have an highly ethical behavior. Usually it’s very difficult to change the ethical behavior of a human – It’s much easier to reprogram the software of a robot probably with consulting of specialists like psychologists.

The main goals in the field of roboethics are:

- Avoid conflicts
- Work for a safe future
- Protect the environment

All these items are in the scope of the IFAC-TC “Supplemental Ways for Improving International Stability – SWIIS”.

6. ETHICS IN END-OF-LIFE MANAGEMENT OF ROBOTS

Until now only the first two goals are discussed. “Protect the environment” e.g. by EoL is definitely a new ethical topic.

The process of engineering is the process of creating solutions that can simultaneously achieve the goals of the problem and remain within certain constraints. These goals and constraints are referred to as “design drivers”. The three most common “design drivers” are

- the cost of the solution,
- the schedule of the project and
- the features of the solution.

These drivers can act as either goals or constraints, depending on the situation.

Ethical considerations can similarly be viewed as “design drivers”, either constraints or goals. Ethical behaviour is either something to be sought or something used to limit the design space. The technical features are analogous to the moral issues at stake in an ethical case.

There are several approaches to the environment that must be understood to really accomplish environmentally-friendly design. Currently, most engineering codes of ethics the components of the environment are given value because they are viewed as important of humankind.

There are four basic strategies in End-of-Life Management (the “4-R” possibilities): Reduce, Reuse, Recycle and Recovery . As the fifth and last option, the strategy landfill is mentioned. This is not EoL options in the narrow sense, but

they are still very important in waste treatment nowadays (Kopacek & Kopacek, 2012).

Each of these tenets has been applied to designs to minimize their environmental impact.

7. SUMMARY AND OUTLOOK

If robots get more and more intelligent, they must deal productively with these inputs and develop them with their own experiences. But an intelligent robot has to be able to explain why he acted in a special situation this way. In this case a substantial condition of a “Roboethics” would be fulfilled. This does not dismiss humans from responsibility, but humans could learn from it.

It should also be noted that Robotics, unlike other sciences, has not yet been affected by practical ethical cases, nor has it had to deal with dramatic situations.

Meanwhile roboethics is neither the ethics of robots nor any artificial ethics, but it is the human ethics of the robots designers, manufacturers, and users. Robotics research and application are increasingly raising ethical implications, related to the more strict interaction between robots and human beings, as well as to the ever closest interaction between robotics itself and biological science (Veruggio, 2010).

It should be pointed out that roboethics is a much wider topic. Many of the particularly interesting issues relate to the ethics in a particular and whether or this use of robots is ethical.

Further research is necessary because there are some open questions.

Comments about robots becoming real partners for people deserve a wider view.

The use of cloud computing in the field of robotics raises issues to privacy and security.

What are the requirements of the robot to seek information to ensure ethical behavior or compliance with robot laws.

A general, theoretical systems approach is necessary in the future.

The system “human-robot” must be quantified.
EoL as a goal of roboethics must be included.

Let’s have a look

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