Ethically Motivated Recommendations for EU Policies and Regulations concerning Robotics and its Convergence with Bionic and Software Agent Technologies.

Chapter · January 2008

CITATION
1

READS
75

10 authors, including:

Jutta Weber
Universität Paderborn
100 PUBLICATIONS **344** CITATIONS
SEE PROFILE

Rafael Capurro
Hochschule der Medien Stuttgart
134 PUBLICATIONS **1,729** CITATIONS
SEE PROFILE

Thomas Christaller
Bewegung & Lebenskunst
77 PUBLICATIONS **478** CITATIONS
SEE PROFILE

Edoardo Datteri
Università degli Studi di Milano-Bicocca
57 PUBLICATIONS **293** CITATIONS
SEE PROFILE

Deliverable D6

SAS 6 - 017759

ETHICBOTS

Emerging Technoethics of Human Interaction with Communication,

Bionic and Robotic Systems

Coordination Action

Structuring the European Research Area

D6: Ethically Motivated Recommendations for EU Policies, Regulations, and Further Research concerning Robotics and its Convergence with Bionic and Software Agent Technologies

Due date of deliverable: April 30th, 2008

Actual submission date: May 5nd, 2008

Start date of project: 1 November 2005 Duration: 24 months + 6 months extension

University “Federico II”, Naples

Revision: Draft

Project co-funded by the European Commission		
Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	x

RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Emerging Technoethics of Human Interaction with Communication, Bionic and Robotic Systems

Deliverable D6: **Ethically Motivated Recommendations for EU Policies, Regulations, and Further Research concerning Robotics and its Convergence with Bionic and Software Agent Technologies**

Editors: Rafael Capurro, Thomas Christaller, Guglielmo Tamburrini

Co-author(s): Rafael Capurro, Thomas Christaller, Edoardo Datteri, Alessandro Giordani, Cecilia Laschi, Michael Mock, Michael Nagenborg, Fiorella Operto, Pericle Salvini, Guglielmo Tamburrini, Gianmarco Veruggio, Jutta Weber

Project funded by the European Community as Coordination Action
Contract SAS 6 Nr. 017759

Revision history

Deliverable administration and summary		
Project acronym: Ethicbots		**ID:** SAS-6-017759
Document identifier:	Ethicbots-D6	
Leading partner: University “Federico II” of Naples		
Report version: 8		
Report preparation date: XXXXXX		
Classification: Confidential		
Nature: Deliverable		
Author(s) and contributors:		
Status:		Plan
		Draft
		Working
	X	Final
		Submitted
		Approved

The Ethicbots Consortium has addressed all comments received, making changes as necessary. Changes to this document are detailed in the change log table below.

Date	**Edited by**	**Status**	**Changes made**
March 4th, 2008	Jutta Weber, Gianmarco Veruggio	Draft	Care robots, military uses of robots
March, 10, 2008	Michael Nagenborg		Edutainment robots, robots in the workplace, relevant legislation
April 7th, 2008	Thomas Christaller, Michael Mock, Fiorella Operto, Gianmarco	Draft	Contributions on learning robots, revisions on edutainment robots, usage of intentional language

	Veruggio		
April 21st, 2008	Guglielmo Tamburrini	Draft	First complete draft
April 28th, 2008	Rafael Capurro	Draft	Revised complete draft
April 28th	Edoardo Datteri	Draft	Addition: Surgery robotics
April 30th	Cecilia Laschi, Pericle Salvini	Draft	Additions on care robots, surgery, and brain-robot communication
April 30th	Editors	Draft	Final revisions

Notice that other documents may supersede this document. A list of latest public Ethicbots deliverables can be found at the Ethicbots information server.

Copyright

Citation

Rafael Capurro, Thomas Christaller, Guglielmo Tamburrini (editors), Rafael Capurro, Thomas Christaller, Edoardo Datteri, Alessandro Giordani, Cecilia Laschi, Michael Mock, Michael Nagenborg, Fiorella Operto, Pericle Salvini, Guglielmo Tamburrini, Gianmarco Veruggio, Jutta Weber (authors), Deliverable D6 – Ethically Motivated Recommendations for EU Policies, Regulations, and further Research concerning Robotics and its Convergence with Bionic and Software Agent Technologies. Ethicbots Consortium, c/o University “Federico II” of Naples

Acknowledgements

The work presented in this document has been conducted in the context of the EU Framework Programme No. 6 and is funded by the European Commission. Their support is appreciated.

The partners in the project are:

University "Federico II", Naples, Physical Science Department and Department of Computer and Systems Engineering, Italy (coordinator)

Fraunhofer Institute for Autonomous intelligent Systems, Sankt Augustin, Germany

Scuola di Robotica, Genova, Italy

Institute of Applied Philosophy, Faculty of Theology, Lugano, Switzerland

University of Reading, department of Cybernetics, UK

Hochschule der Medien University of Applied Sciences, Stuttgart, Germany

LAAS-CNRS, Toulouse, France

Scuola Superiore Sant'Anna, Pisa, Italy

University of Pisa, Department of Philosophy, Italy

Middlesex University, Interaction Design Centre, School of Computing, London, UK

More information

Public Ethicbots reports and other information pertaining to the project are available through Ethicbots public information service under http://ethicbots.na.infn.it.

Table of contents

Executive summary

Ethical issues arising from the interaction of humans with robots have been the main focus of the ETHICBOTS FP6 Science and Society Coordination Action. In view of the convergence and increasing integration of robotics with bionics and software agent research, the ETHICBOTS core business reaches out to include selected ethical issues arising from the interaction of humans with softbots and bionic devices. Indeed, IC technologies enable robots to interact remotely with software agents hosted by other robots or computer systems; and robotic systems are embedded as mechatronic components of bionic systems which are formed by both biological and machine parts.

In the ETHICBOTS project, the promotion and the protection of fundamental rights have provided the chief coordinates for the analysis of ethical issues and the shaping of related recommendations.

This report presents ethically motivated recommendations for further research about the ETHICBOTS domain of inquiry and for the development of policies and regulations concerning robotic technologies and their integration with technologies in bionics and softbot AI research.

Recommendations about robotic technologies in general concern learning robots, stability and uncertainty issues in robotics, position of humans in the control hierarchy, robotic action legibility, privacy, race and class issues, gender issues, and misleading uses of intentional language to describe robot behaviour.

Recommendations about domain-specific human-robot interactions concern care robots, edutainment robots, robotic surgery, robot in the workplace, and military uses of robots.

A final section is devoted to ethical issues concerning bionic technologies for interfacing human brains to robots.

Preamble

Goals of the ETHICBOTS project

Ethical issues arising from the interaction of humans with robots have been the main focus of the ETHICBOTS FP6 Science and Society Coordination Action (1 November 2006 through 30 April 2008).

In view of the convergence and increasing integration of robotics with bionics and software agent research, the ETHICBOTS core business reaches out to include selected ethical issues arising from the interaction of humans with softbots and bionic devices. Indeed, IC technologies enable robots to interact remotely with software agents hosted by other robots or computer systems; and robotic systems are embedded as mechatronic components of bionic systems which are formed by both biological and machine parts.

Interactions of human beings with robotic systems - either in isolation or in combination with softbot and bionic devices - notably include shared or delegated action control. On the part of the robotic system, action control involves sensori-motor coordination capabilities, in addition to varying combinations of machine perception, learning, reasoning, planning, and communication capabilities.

Distinctive ethical issues arise from sharing action control with or delegating it to machines possessing some of the above sensori-motor and cognitive capabilities. The ETHICBOTS consortium has pursued the prior goal of identifying and analysing novel ethical issues arising in this special human-machine interaction context.

Crucial enabling factor for this analytical undertaking has been the pluridisciplinary character of the group of researchers forming the ETHICBOTS consortium, whose range of expertise spans robotics, artificial intelligence, anthropology, moral philosophy, philosophy of science, cognitive science, gender studies, and science & technology studies.

In the ETHICBOTS project, the *promotion* and the *protection* of fundamental rights are the chief dimensions along which ethical issues

have been analysed. The focus on the promotion and protection of fundamental rights has enabled the consortium to achieve a comprehensive ethical perspective which carries with it significant policy making implications.

This report presents ethically motivated recommendations for further research about the ETHICBOTS domain of investigation and for the development of policies and regulations concerning robotic technologies and their integration with technologies in bionics and softbot AI research. These recommendations are grounded into the analysis of both ethical issues and their broad policy making implications carried out by the ETHICBOTS working group.

Scientific and Technical Background

For the scientific and technical underpinning of the recommendations presented in the ensuing sections, the reader is referred to the other deliverables released by the ETHICBOTS consortium, and in particular to

D1: Analysis of the State of the Art in Emerging Technologies for the Integration of Human and Artificial Entities

D2: Methodology for the Identification and Analysis of Techno-Ethical Issues

D4: Analysis of National and International EU regulations and Ethical Councils Opinions Related to Technologies for the Integration of Human and Artificial Entities

D5: Techno-Ethical Case-Studies in Robotics, Bionics, and Related AI Agent Technologies

Technology foresight background

A triage of technologies, projects and systems was carried out by the ETHICBOTS consortium in order to distinguish issues of rights protection and promotion that concern society now from issues that may possibly concern society in a fairly distant future only. This triage was carried out

applying *imminence*, *novelty*, and potential social *pervasiveness* selection criteria (see Ethicbots deliverable D2, p. 42ff). It is worth noting that the ETHICBOTS consortium, by endorsing these selection criteria, has opted for attending in a marginal way only to issues concerning attribution of rights and responsibilities to robots and to issues reflecting broad transhumanist views and aspirations.

Another temporal refinement discussed and introduced by the ETHICBOTS consortium concerns the distinction between long-term visions driving research in robotics and the near-term perspectives of robotics research and technology transfer (see deliverable D5). Long-term visions are taken into account in this report chiefly by means of ethical *monitoring* recommendations, which mostly point to the need for further ethical inquiry and bear no direct regulatory implications.

The need to distinguish between long-term vision and near-term perspectives for the purpose of issuing recommendations about policies and regulations is particularly evident in the case of service and personal robotics, which presently attract considerable attention from general public and the media. A long-term goal of service and personal robotics is to enable rich and flexible human-robot interactions in homes, offices, and other environments that are specifically designed for human activities. Results obtained in this rapidly growing area of research are impressive when gauged by the yardstick of scientific and technological advancement. Their near-future practical significance, however, is more difficult to assess. Indeed, near future projections licensed by robotic demonstrations concern restricted forms of cooperative behaviour. And major theoretical and technological problems have to be solved before deft interactive robots will step out of research labs and will be ushered in our homes. (See Deliverables D1, D2, and D5.)

Framework provided by international principles and charters

Crucial for the interpretation of fundamental rights *promotion* and *protection* in the context of robotics and related softbot and bionic technologies are the articles included in the six sections of the Charter of Fundamental Rights of the European Union of 28 September 2000, which concern the promotion and protection of dignity, freedoms, equality, solidarity, citizenship, and justice.

In addition to this, significant to ETHICBOTS consortium analyses and recommendations have been the following:

The European Union Treaty and in particular Article 6 of the common provisions concerning the respect for fundamental rights;

Directive 2002/58/EC of the European Parliament and of the Council of 12 July 2002 concerning the processing of personal data and the protection of privacy in the electronic communication sector;

The Principles of Good Governance stated in the European Governance White Paper issued by the EC on 25 July 2001, and in particular the principles of openness, participation, effectiveness, and coherence;

The Opinion “Ethical aspects of ICT implants in the human body” adopted by the European Group on Ethics in Science and Technology (EGE) on 16 March 2005;

The Declaration of Principles of the World Summit on the Information Society of 12 December 2003, in particular of Article 58 on the use of ICTs and Article 59 on the abusive uses of ICTs;

The Council of Europe Convention for the Protection of Human Rights and Dignity of the Human Being with regard to the Application of Biology and Medicine: Convention on Human Rights and Biomedicine, signed on 4 April 1997 in Oviedo;

The United Nations Convention on the Rights of the Child. Adopted and opened for signature, ratification and accession by General Assembly resolution 44/25 of 20 November 1989 entry into force 2 September 1990, in accordance with article 49;

The United Nations Convention on the Rights of Persons with Disabilities. Adopted on 13 December 2006 during the sixty-first session of the General Assembly by resolution A/RES/61/106;

The Geneva Conventions and Additional Protocols.

In the context of specific areas of applications additional documents have been considered, which included the Council Directive of 12 June 1989

on the introduction of measures to encourage improvements in the safety and health of workers at work (89/391/EEC), the United Nations United Nations Convention on prohibitions or restrictions on the use of certain conventional weapons which may be deemed to be excessively injurious or to have indiscriminate effects (1980), the United Nations Optional Protocol to the Convention on the Rights of the Child on the sale of children, child prostitution and child pornography (2000), and the Recommendation of the European Parliament and of the Council of 20 December 2006 on the protection of minors and human dignity and on the right of reply in relation to the competitiveness of the European audiovisual and on-line information services industry (2006/952/EC).

An overview of the ethical regulations taken into account within the ETHICBOTS project was presented in Annex to Deliverable D4.

Scope of the present recommendations

Consistently with the goals of the ETHICBOTS project, these recommendations focus on shared or delegated action control arising in interactions of human beings with robotic systems. Softbot and bionic devices are taken into account here insofar as they may be combined with robotic devices. Accordingly, this report is not concerned with softbot technologies in general, as these are developed in Artificial Intelligence research, or with bionic technologies in general, as these are developed in bioengineering research.

These recommendations address ethical issues, but are in no way confined to possible or actual threats to fundamental rights posed by robotic and related softbot and bionic technologies. Indeed, a central goal of ETHICBOTS has been that of encouraging, on the basis of an ethically motivated reflection, responsible scientific and technological research. Accordingly, the potential of robotic and related technologies to promote fundamental rights is emphasized throughout the present report.

The ETHICBOTS consortium did not address explicitly the intercultural dimensions of robotics and related bionics and AI technologies. However, the consortium participants deem that intercultural issues play, in a globalized world, an important and complex role that should be investigated by EC supported research efforts in the near future.

The ETHICBOTS consortium is aware of possible positive and negative implications for developing countries of robotic technologies and related bionic and AI technologies. This issue has been considered here with regard to specific applications only, for instance with regard to robotic surgery. Additional and more comprehensive ethical research and monitoring are clearly needed.

The ETHICBOTS consortium has not discussed in depth the issue of the ecological impact of robotics and related bionic and AI technologies. However, the consortium is aware that the widespread use of robots may give rise to extensive waste disposal and recycling problems. The consortium has not examined potential uses of robotics for environmental protection either. Both issues are closely interrelated and should be thoroughly examined and systematically monitored by future EU projects.

Finally, one should take notice of the fact that the order in which topics are listed in this report is not supposed to convey any hierarchical order between them.

Robotic Technologies: Ethical Monitoring and Recommendations

Learning robots

Machine learning will play a central role in robotics for the purpose of developing versatile service robots in general, and personal robots in particular. There are theoretical and practical limitations in our ability to explain, predict, and control the behaviour of learning robots in their interactions with humans. These epistemic limitations have a significant impact on human autonomy issues, physical integrity, moral responsibility and liability ascription problems (see section on learning robots in ETHICBOTS Deliverable D5).

It is recommended that in the ethical monitoring and evaluation of robotic systems that are designed to interact with humans, one explicitly and carefully attend to the role, if any, of machine learning techniques. In particular, ethical monitoring is required of the potential impact of learning technologies on moral responsibility and liability ascription problems in service and personal robotics, in addition to physical integrity, human autonomy and robotic system accountability issues.

Stability and Uncertainty

Robotics research and technological transfer efforts are extensively concerned with the stability of robot sensori-motor behaviour and related uncertainty issues (see ETHICBOTS Deliverable D5).

It is recommended that in the ethical monitoring and evaluation of robotic systems that are designed to interact with humans, stability and uncertainty issues be systematically and carefully attended to, assessing their impact on moral responsibility and liability ascription problems, on physical integrity, and on human autonomy and robotic system accountability issues.

Position of humans in the control hierarchy

Ethical reflection does not justify the exceptionless rule that every individual robotic action be submitted to human supervision and approval before its execution. This is particularly evident when human-in-the-loop conditions jeopardize timely robotic responses, possibly leading on this account to violation of task constraints and increased risk situations.

It is recommended that in human-robot shared action control provisions be made for assigning humans the higher rank in the control hierarchy which is compatible with cost-benefit and risk analyses. Furthermore, it is recommended that robotic systems which are justifiably allowed to override human decisions or to act independently of direct human control or supervision be systematically evaluated from an ethical viewpoint.

Robotic action and ethically motivated design standards

Increase of legibility and predictability of robotic behaviour by humans is a central goal of personal robotics. From an ethical viewpoint, the promotion and protection of human dignity and autonomy, and the related reduction of interaction risks, are powerful motivations for the identification of design standards concerning legibility and predictability of robot behaviour. Promotion and support of research on the identification of such standards is recommended, involving, e.g., standards about recognizability of robot action-types, and the design of robot morphological features enabling human observers to recognize the robot as a machine and to evaluate its range of action and direction of motion.

Privacy

IC technologies enable robots to interact remotely with any kind of software agents hosted by other robots or computer systems. Indeed, the broad vision driving research on converging IC and robotic systems includes service and personal robots that are fully integrated with the internet and the world of software agents. Accordingly, research on converging IC and robotic technologies should be promoted and

supported also in view of their tremendous potential for jointly extending human action and human information and communication capabilities.

However, one should be careful to note that IC technologies enable one to make remotely accessible “sensitive data” about humans interacting with a robot. In particular, this information can be further processed by any kind of connected “intelligent” softbot system which may infer and distribute unauthorized user profiles. And clearly, this structured information can be used to influence the behaviour of interacting humans in illegitimate ways. Accordingly, it is recommended that any type of robot interacting with humans be subject to a preliminary privacy impact assessment, which includes, but is not limited to potential violations of current privacy regulations and policies.

Further research on the possibility to use privacy enhancing technologies in the field of robotics is also recommended.

Race, class, gender, intentional language

Suitable policies should be developed to prevent the modelling of human-robot relationships after discriminatory or impoverished stereotypes of, e.g., race, class, gender, personality, emotions, cognitive capabilities, and social interaction. In particular, disregard of relevant EU equality regulation and policies should be avoided, and one should carefully consider the opportunity of providing suitable interpretations or extensions of extant regulations with respect to the human-robot interaction context.

In robotics, current uses of words such as 'knowledge', 'intelligence', 'representation', 'intention', 'emotion', 'social', 'agent', 'autonomy', and 'humanoid' are potentially misleading - insofar as it is thereby suggested that typically human mental properties can be unproblematically attributed to technological artefacts, disregarding in this respect current limitations of state-of-the art robotic systems. It is recommended that actions be taken to foster awareness among science writers, journalists and other communication workers of the potential misuse and pitfalls of this kind of language. Moreover, the EC may consider the possibility of

requiring an evaluation from this psecific perspective of the language used in proposals submitted within framework programmes and other European level research initiatives.

Recommendations about Domain-Specific Human-Robot Interactions

Let us now turn to consider applications of robotic systems in specific domains potentially involving extensive forms of human-robot interaction.

Care Robots

Care robots have the clear potential for promoting the right of people to live a life of independence and social participation. Prospective applications in the near future (within 5 years) are relatively limited, but the vision driving care robot research encompasses a wide range of applications (See ETHICBOTS Deliverable D1, p. 18. For a survey of technologies, systems, and projects, see D1 pp. 78-93.) Research and technological transfer in this field should be strongly encouraged and explicitly driven by opportunities for promoting fundamental rights.

These opportunities must be pursued while protecting fundamental rights from potential threats which arise if care robots are used to replace and possibly to dispense altogether with human care in the assistance to human beings in general, and to ill, disabled or elderly people in particular. A decrease of direct human interactions induced by robotic replacements may be highly detrimental to the well-being of assisted people.

In accordance with this warning, the introduction of robotic care systems should be monitored, properly justified in terms of the dignity and well-being of their human users, and planned in view of expected improvements in the allocation of human resources for assistance purposes. The EC should investigate the opportunity of submitting the deployment of care robots to the approval of ethical committees taking proper account of the above dimensions of the problem. From a technical point of view, research should be supported in the design and development of care robots based on the concept of “appliance”, i.e. a helpful device helping in everyday life but operated by a human being.

Support of interdisciplinary research (including social sciences and humanities) on well-being in disabled and elderly people is recommended, which focuses on visions of assistive technologies in general and robotic assistance in particular. These research efforts should crucially involve potential users and human care-givers.

Technologically-informed education should be promoted in connection with care robots, in order to improve public opinion formation and participation in techno-ethical discussions about care robots. Similarly, further development and support of deliberative technology assessment procedures concerning care robots is recommended too.

Edutainment robots

Robots designed for educational purposes (say, robotic construction kits for schools or robots acting as museum tour guides; but see, for wider repertoires of systems and educational purposes, Deliverable D1, pp. 46-59 and pp. 93-101) have the potential to contribute to improve education, cultural life, creativity, and to enhance human cognitive and emotional capabilities. Research on edutainment robots should be explicitly encouraged and supported on these grounds, making sure that discriminatory or impoverished stereotypes are avoided which concern, e.g., race, class, gender, personality, emotions, cognitive capabilities, and social interaction.

It is recommended that one treats on a par with media technology robots that are designed and sold for entertainment purposes. Therefore, existing regulations on media content may be applied on such robots, both on the European level and on the level of the EU member states. These regulations are likely to provide an effective level of protection for minors and for human dignity.

Commentato [Michael N1]: The official name of the EU document on media regulations is: "Council Recommendation of 24 September 1998 on the development of the competitiveness of the European audiovisual and information services industry by promoting national frameworks aimed at achieving a comparable and effective level of protection of minors and human dignity" – Therefore, I would delete "more in general".

Some robotic systems take on the external appearance of humanoid characters or animals. Presently, these superficial analogies are not, in general, accompanied by deeper relational, cognitive or emotional similarities. It is recommended that psychological research on the use of robotic toys and entertainment systems resembling humans or animals be promoted and supported, notably with the aim of investigating and detecting possible cognitive, emotional, and relational deficiencies

arising from early age failure to categorize these robots and distinguish them properly from animals and humans. Similarly, psychological research should be encouraged on possible negative consequences of deceptive simulation of emotions and the related incapability of distinguishing between these and genuine expressions of emotions.

If the EC will further support robotic entertainment technologies and systems, it is recommended that intended kinds of entertainment be clearly specified and ethically evaluated.

Special caution should be used in the case of sex robots, which have been occasionally promoted in public discussion on the medically uncertain ground of sex therapy (let alone highly questionable claims to the effect that robots will eventually replace human prostitutes). In case the EC should consider financial support of research on sex robots in the context of medical therapy, it is recommended that this be motivated on the basis of strong medical evidence.

Commentato [Michael N2]: I would like to focus on "Sex robots" here, since "wargaming" is part of the regulation pointed to above.

Sex robots with child-like appearances should be banned under any circumstance, in accordance with the United Nations „Optional Protocol to the Convention on the Rights of the Child on the sale of children, child prostitution and child pornography“ (2002).

Robotic surgery

Robotic systems in surgery have the clear potential for promoting fundamental rights, by improving the quality of medical interventions and protecting the patient's physical integrity. In addition to this, robotic surgery systems promise to reduce post-operatory problems, and to allow for faster recovery.

However, in order to protect physical integrity and well-being, extensive assessment studies are recommended concerning control which is shared between human surgeon robot, and communication technologies in tele-operation, by highlighting relevant responsibility and liability issues (see the detailed case-study on ROBODOC in D5).

Thorough cost-benefit analyses are recommended, in order to assess which benefits can flow in the near future from robotic tele-operation

technologies, especially in the way of improvements of the quality of life of people living in developing countries which lack specialized hospital facilities. Special attention must be devoted to problems of installation, usage, and maintenance expense reduction which are presently hardly affordable by developing countries. Specific research should be supported for the porting of the expensive technologies related to surgical robotics to low-cost technologies that are more widely accessible.

Replacing humans in the workplace

It is to be expected that robots will increasingly replace human workers in manufacturing processes. The ethical dimension of replacing of humans by machines has been a key issue concerning the social impact of robotics ever since the introduction of the first industrial robots.

On the one hand, automation technologies in general, and robotic technologies in particular have significantly contributed to the health quality and security of workers (for a recent development in this sense see the robotic street cleaner case-study in D5). Arguably, the replacement of humans by robots will serve the promotion of fundamental rights in other ways, e. g., by contributing to reduce child labour exploitation.

On the other hand, robotic automation in the workplace calls for ethical evaluation, monitoring, and warning for the purpose of protecting fundamental rights.

It is recommended that more research be promoted and supported on the ethical implications of the impact of robots replacing humans in the workplace. In particular, the expectation that mostly workers with low qualification levels will continue to be replaced by machines in the near future suggests the need for sustained research about the ethical impact of newly emerging robotic substitutes for these forms of human labour.

Research on the impact of human-machine replacement should be encouraged from the perspective of the robotic-divide too, since there is hardly any systematic knowledge about the effects which the action of

replacing humans by machines in one country brings about on the job market of another country.

Remote control and cooperation in the workplace

Robotic systems can be tele-operated by people who are possibly located in another country. It is recommended that existing regulations be scrutinized to assess whether questions of responsibility and liability for acting in tele-presence are properly taken into account. These regulations should comprise international conventions regulating situations in which, e.g., the human operator of a robotic system is located in a different country as the robot providing service to someone who is citizen of yet another country. A related question to be investigated is whether one should be allowed to tele-operate from within Europe a robot located in countries which do not meet European standards for machine safety.

In situations involving mixed Human-Machine teams, it is no longer possible to reduce human-machine-interaction to a minimum, which seems to be at the core of existing regulations, i.e. Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery. It is recommended that a new approach be developed to address issues of safety involving interaction with new kinds of machinery, like service and personal robots. It is also recommended that the obligation to provide users with information on how to operate robots expressed in existing regulations (Directive 2006/42/EC, Directive 89/391/EEC) be re-evaluated and possibly revised in light of the likely development of more versatile and autonomous robots.

Military uses of robots

Military research in robotics is being extensively supported. Both ground and aerial robotic systems have been deployed in warfare scenarios. It is expected that an increasing variety and number of robotic systems will be produced and deployed for military purposes in many developed countries.

In view of these new military scenarios, a European level agreement should be sought to the effect that robots are to be counted with regard

to the Conventional Forces in Europe Treaty (CFE). More important, it is recommended that aerial and other combat robots be included in the preventive arms control agenda.

In view of current limitations of robotic technologies, robots do not achieve human-level perceptual recognition performances that are crucial, e. g., to distinguish friends or by-standers from foes. Accordingly, tight control on and even a moratorium on autonomous combat robots should be considered. This could be achieved by a joint effort of the EU member states – preferably involving other OSZE countries and the UNO. Related analyses of autonomous robotic weapon systems are needed with regard to international warfare law, in view of the fact that present robotic systems fail to match human performance in discriminating between soldiers, soldiers that surrender, civilians, etc.

A detailed comparative analysis of warfare robotic technologies is recommended with respect to control policies adopted towards other kinds of weapons, such as the 1995 protocol banning blinding laser weapons or the 1972 BTWC which prohibits the development of biological weapons.

The EU member states should support research on the predictability of behaviour and safety of aerial combat systems and consider, in the light of results thus obtained, the possibility of restricting overflight rights on densely populated European territory.

In view of stability, uncertainty and other kinds of unpredictability issues concerning robotic systems at large (see D5), it is recommended that one considers an international agreement to ban nuclear bombs and missiles from the equipment of autonomous robotic systems.

An up-to-date definition of robot for military uses, especially in the context of arm export, regulation and control must be provided (see also D4, section 2.4.2, Armed Forces).

In the framework of discussion about autonomous weapon systems, the promotion and support of interdisciplinary research is recommended on the risks of misuse of new robotic technologies and consequences for international security, explicitly including civil-military interaction and

exchanges, and the operational capabilities of small groups and arms-producing countries.

The further development of a broad ethical framework as an enabling factor for the public to participate in discussions on dual use of robots is highly desirable, together with deliberative technology assessment procedures (for example consensus conferences) backed by technologically-informed education initiatives. Suitable policies and actions fostering awareness about the dual use of robots are highly recommended at the level of European society. Support of extensive initiatives in dual use problem dissemination and interdisciplinary techno-ethics community building is recommended too.

Connecting the human brain to robots

Bionic technologies fall in the purview of the ETHICBOTS project insofar as these allow for the interfacing of the human brain with robotic systems. Human-robot hybrid bionic systems have been shown to provide effective therapeutic means to restore lost motor functionalities. In addition to this, current bionic inquiries into human-robot hybrid systems demonstrate a wide spectrum of possibilities for enhancing human sensori-motor capabilities in healthy human beings. These latter possibilities, however, are demonstrated by proof-of-concept experimental work only. Their present or imminent interest for healthy users is not evident in the light of cost-benefit considerations. Thus, on the basis of the triaging dimensions adopted by the ETHICBOTS consortium, the present section concentrates on the more imminent – and mostly therapeutic - applications of technologies enabling one to interface the human nervous system with robotic systems. These notably include both invasive and non-invasive Brain-Computer Interfaces (BCIs).

Implant technologies for connecting nervous systems to robots

In connection with invasive implants enabling connections between nervous systems and robotic systems (see specific sections in D1 and D5), the ETHICBOTS consortium endorses the ethical analyses provided in the above mentioned opinion on ICT implants in the human body by the European Group on Ethics in Science and New Technologies to the European Commission: ‘Ethical aspects of ICT implants in the human body’, Opinion No. 20, Adopted on 16/03/2005. However, it is recommended that the EGE Opinion be regarded just as a starting point for further ethical research, which is clearly needed in view of the fact that this research is rapidly evolving and its results directly affect the brain and correlated mental capabilities. Ethical research should be promoted and supported on ICT implants in general, and implants interfacing the nervous system with robotic systems in particular.

Non-invasive BCIs and robotic system control

Non-invasive BCIs involve no implant technology and are mostly used to control computer or robotic devices in therapeutic applications enabling one to restore lost communication and motor capabilities (see specific D5 section on such devices). BCIs have been shown to provide effective means to restore lost communication and motor capabilities in patients paralysed by spinal chord injuries or muscular dystrophies, thereby helping severely disabled people to increase their independence and to participate in social life. Brain-actuated devices presently include virtual computer keyboards, robotic wheelchairs, and robotic manipulators.

The concept of direct brain-robot communication emerging from the recent progresses made in this young field of research is to build on these initial results and technologies in order to extend communication and control capabilities of both disabled and non-disabled individuals. It is recommended that extensive ethical research be promoted and supported concerning both the imminent therapeutic applications of BCI-robot integration technologies and the emerging promise of BCI-robot integration. In particular, additional ethical research is needed along the following chief dimensions.

Autonomy

BCI-robot integration has a clear potential for promoting autonomy in people affected by severe motor disabilities. However, a trade-off arises in view of the need of relying on shared control of action due to the relatively limited range of action commands that present-day BCI technologies enable one to communicate to robots. Further research on the promotion and protection of personal autonomy is recommended in connection with this particular trade-off and the possibility of misinterpreting user commands depending on brain plasticity and limitations of machine learning methods.

Responsibility

Misinterpretations of user intents and commands expressed by means of a BCI may depend on theoretical and practical limitations of sensor technology and machine learning methods in computer science. More

research is needed in order to identify and analyse moral responsibility and liability ascription issues arising from these technological limitations in the context of robotic systems whose control policy involves BCI input commands.

Distributive justice

Further research is recommended on distributive justice issues arising in connection with non-discriminatory access to therapeutic BCI-enabled robotic systems and the distribution of limited healthcare resources. Special attention should be paid to an analysis of preventive medicine uses of BCIs to preserve sensory motor and cognitive abilities in degenerating diseases leading to locked-in states.

Privacy

More research on privacy protection issues is recommended in connection with mental and brain state reading possibilities afforded by BCI research, and the broadcasting of information about brain and mental states which is made possible by computers and robots that are connected to BCIs. This recommendation extends the releated recommendations on privacy and robots made in the previous section.

Personhood

Further research on the protection of personal integrity is recommended along the dimensions of personality changes, personal identity persistence, and social identity and identification problems which may arise from both invasive and non-invasive BCI-enabled connections with robotic systems. In particular, ethical problems related to the narrative dimension of personal identity, as well as the bodily and mental continuity criteria for personal identity stand in need of more extensive investigation, which significantly bear on legal issues concerning autonomy, liability and responsibility arising in this technological context of human-machine inetraction.