

ICAR 2011 WORKSHOP
Urban Service Robotics: Challenges and Opportunities

THE 15TH INTERNATIONAL CONFERENCE ON ADVANCED ROBOTICS
June 20, Tallinn

Workshop on
“Urban Service Robotics: Challenges and Opportunities”

ORGANISERS

– *Barbara Mazzolai* –

Istituto Italiano di Tecnologia, Italy

– *Pericle Salvini* –

Scuola Superiore Sant’Anna, Italy

Workshop Overview

- The programme
- Motivations & Objectives
 - Introduction: challenges and opportunities for service robots operating in urban environments



The programme (1/2)

- **09.00-09.45** 'Workshop Welcome and Introduction: Urban Service Robotics: Challenges and Opportunities', by **Dr. Pericle Salvini**, The BioRobotics Institute, Scuola Superiore Sant'Anna, Pisa, Italy
- **09.45-10.35** 'Legal problems and challenges on Network Robot Systems in Japan', by **Dr. Norihiro Hagita**, ATR Intelligent Robotics and Communication Laboratories, Kyoto, Japan
- **10.35-11:00** 'Urban Service Robotics in the 7th Framework Programme and beyond', by **Dr. Bjoern Juretzki** European Commission, Bruxelles, Belgium
- **11.00-11.30** *Coffee break*
- **11.30-12.15** 'From virtual to reality: How we test and evaluate new automatic transport system', by **Dr. Clement Bousard**, INRIA, IMARA Team, Le Chesnay, France
- **12.15-13.00** 'Introduction of a Low-Cost Autonomous Navigation for a Grounded Vehicle in Urban Environment', by **Dr. ChangHwan Kim**, Center for Bionics, Biomedical Research Institute, Korean Institute of Science and Technology, Korea
- **13.00-14.00** *Lunch break*



The programme (2/2)

- **14.00-14.45** 'Societal Acceptance of Intelligent Robotic Systems: The Role of Performance Evaluation, Benchmarking, and Standardization', by **Dr. Raj Madhavan**, University of Maryland College Park & National Institute of Standards and Technology, Maryland, United States
- **14.45-15.30** 'The DustCart service robot at work in the town of Peccioli: focus on social and legal challenges', by **Dr. Barbara Mazzolai**, the Italian Institute of Technology, Genoa, Italy
- **15.30-16.00** *Coffee break*
- **16.00-16.45** 'Embodiment, self and consciousness. Modules of a social interactive and biologic inspired humanoid robotics', by **Dr. Gregor Fitzi**, Oldenburg University, Oldenburg, Germany
- **16.45-17.30** Round table (all speakers invited)
- **17.30** End of workshop



The round table

- All speakers invited!
- Main themes that will be discussed:
 - Technology
 - Safety
 - Law
 - Market
 - Social acceptance





A Special Issue...

Advanced Robotics, No. 24, Vol.13, 2010

Special Issue on Legal and Safety Constraints for Service Robots Deployment

Guest Editors: Pericle Salvini and Cecilia Laschi

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- Strategy on Safety Function Implementation: Case Study Involving Risk Assessment and Functional Safety Analysis for a Power Assist System *by Suwoon Lee and Yoji Yamada*
- Socially Acceptable Pre-collision Safety Strategies for Human-compliant Navigation of Service Robots *by Kun Qian, Xudong Ma, Xianzhong Dai and Fang Fang*
- False Alarm Metrics for Human Robot Interaction in Service Robots *by Mohan Rajesh Elara, Wijerupage Sardha Wijesoma and Changjiu Zhou*
- Liability in robotics: An International Perspective on Robots as Animals *by Richard Kelley, Enrique Schaerer, Micaela Gomez and Monica Nicolescu*
- Influence of the Privacy Issue in the Deployment and Design of Networking Robots in European Urban Areas *by Alberto Sanfeliu, Maria Rosa Llácer, Maria Dolors Gramunt, Albert Punsola and Yuji Yoshimura*
- Beyond Robot Ethics, On Legislative consortium for Social Robotics *by Yueh-Hsuan Weng*

Motivations & Objectives



DustBot

Networked and Cooperating Robots for Urban Hygiene

FP6-045299

The DustBot project is aimed at designing, developing, testing and demonstrating a system for improving the management of urban hygiene based on a network of autonomous and cooperating robots, embedded in an Ambient Intelligence infrastructure.

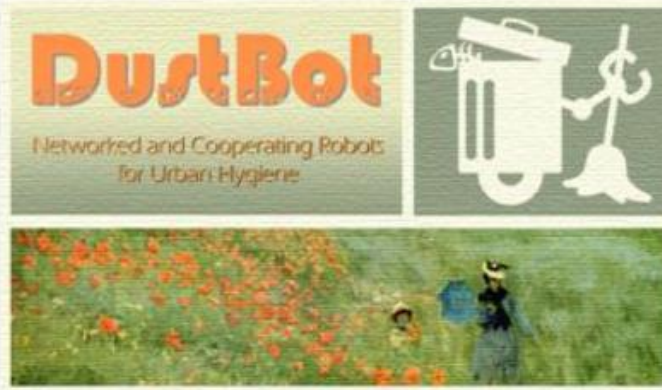


Project Details

Start Date: 01-12-2006

End Date: 30-11-2009

Duration: 36 months



Partnership

- SSSA (I)
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with technical support by:

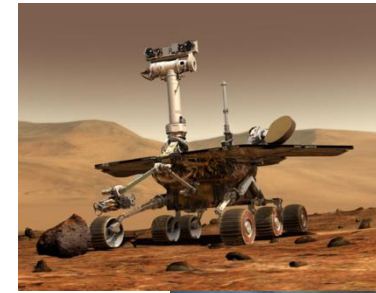
- STMicroelectronics (IT-FR)

www.dustbot.org



The “paradigm shift”

- From industrial to service robotics
 - Robots move closer to human beings

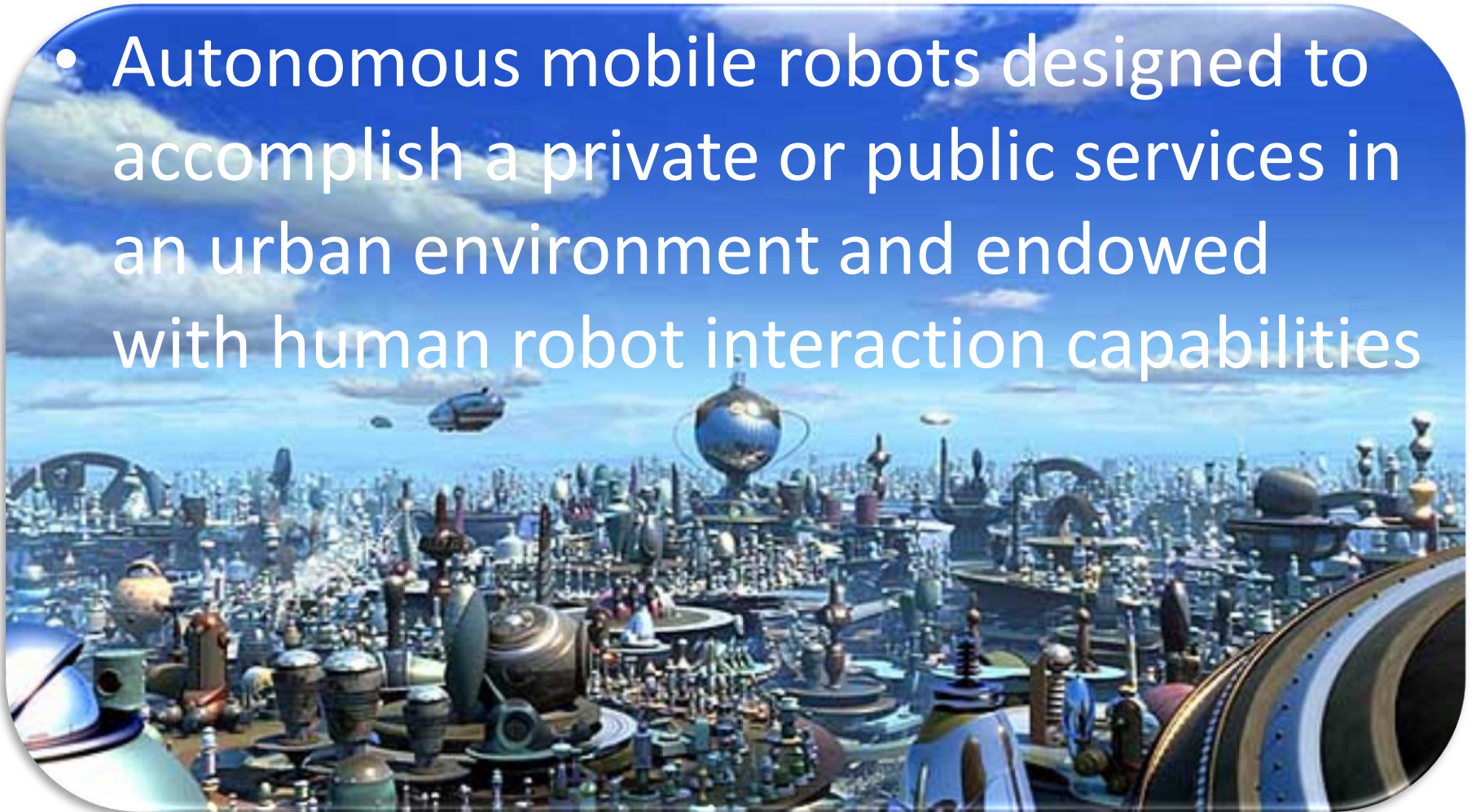


- One of the next frontiers of robotics is the “urban environment”



What is urban robotics?

- Autonomous mobile robots designed to accomplish a private or public services in an urban environment and endowed with human robot interaction capabilities

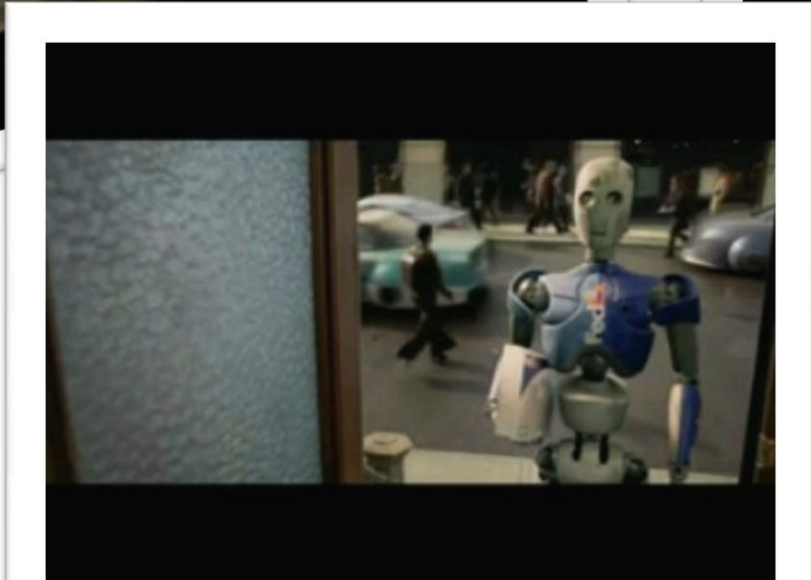


Current applications of service robots in urban areas

- Cleaning of squares and streets
- Garbage collection
- Human transportation
- Human guidance
- Security
- Objects transportation
- Etc.



Snapshots from future applications?



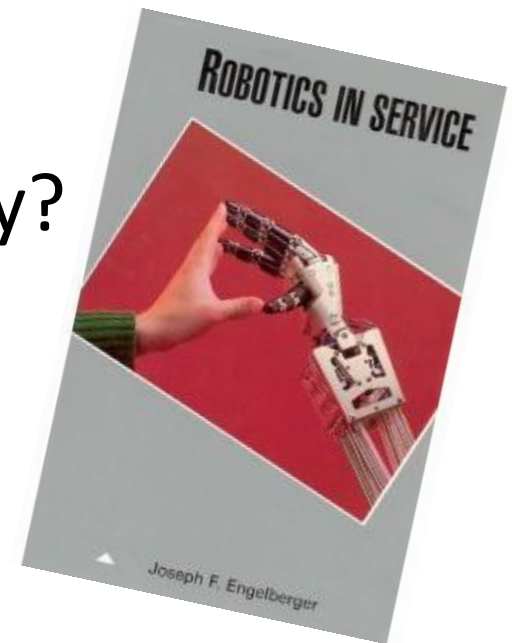
What benefits and for whom?

- Citizens, the environment and society at large
- E.g.: Potential benefits of “Human transportation” applications:
 - Improving people mobility
 - Improving safety
 - Reducing urban pollution
 - Reducing architectural barrier
 - Cost reduction



Major Challenges

1. Technology: is it mature?
2. Safety standards: do they exist?
3. Legal regulations: do we need new laws?
4. Market: is there a market?
5. Social acceptance: are we ready?





URBAN CHALLENGE

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The DARPA Urban Challenge features autonomous ground vehicles conducting simulated military supply missions in a mock urban area. Safe operation in traffic is essential to U.S. military plans to use autonomous ground vehicles to conduct important missions. [Read more.](#)

News

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- All DARPA Urban Challenge events are open to the public and free of charge.

Quote

"It was an important step to have autonomous ground vehicles that can navigate and drive across open and difficult terrain from city to city. But the next big leap will be an autonomous vehicle that can navigate and operate in traffic, a far more complex challenge for a 'robotic' driver. So this November we are very excited to be moving from the desert to the city with our Urban Challenge."

Dr. Tony Tether, Director, DARPA, testified before the U.S. House of Representatives, House Armed Services Committee, Terrorism and Unconventional Threats and Capabilities Subcommittee, on March 21, 2007.



Solutions

› Transport

Cybernetic Transport Systems

Interactive rides

Transport of goods

Refueling robots

› Cleanliness

› Security

› Healthcare

› Others

›

Advanced Robotics Solutions CYBERNETIC TRANSPORT SYSTEMS

Our CTS aim at providing **solutions to automate individual or collective transport** of people in sites open to public.

A CTS is a fleet of driverless vehicles coordinated by a supervision system, and operating as a public transport service. If the SHUTTLE mode (scheduled circuits) is the basic mode, vehicles can also be used on a on-demand basis.

The fleet is made of Cybercars, which are automated electric vehicles, being able to operate in dual-mode (automatic or manual). For certification reasons, CTS are not yet available on public roads, only in private sites.



robuCAB4



CyCab



robuCAB22

Technology

- 3 Rs: ready, reliable and robust?
 - Localisation systems
 - Environmental perception
 - Autonomy (energy)
 - Autonomy (control)



Safety

A green and white service robot is operating on a city street. The robot has a rounded, boxy body with a white front section and a green top section. It is positioned in the center of the frame, moving towards the right. In the background, several pedestrians are walking, including a man in a blue shirt and a woman in a blue patterned dress. The street is paved with cobblestones, and there are buildings and a car visible in the background.

- Urban service robots:
 - Highly unpredictable environments (i.e. no tracks or dedicated roads)
 - Interaction with human beings and other road users
- Lack of:
 - Safety standards for software and hardware
 - Risk assessment procedures

Solutions

Modules

› Transport

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› Security

› Healthcare

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robuCAB4



CyCab



robuCAB22

Safety standards

- Lack of specific risk evaluation methods and of safety standards for service robots (impossibility to rely only on existing EU Directives, such as Machinery Directive 2006/42/EC, and EU regulations for vehicles using public roads, that is Directive 70/156/EEC and Directive 92/61/EEC)
- ISO TC 184/SC 2/WG 7 Personal care safety (expected 2012)

The screenshot shows the ISO website interface. At the top left is the ISO logo and the text "International Organization for Standardization". To the right is the tagline "International Standards for Business, Government and Society" and a search bar with a "Search >>" button. Below this is a navigation menu with "Home", "Products" (highlighted in red), "Standards development", "News and media", and "About ISO". On the right side of the menu are links for "For ISO Members", "FAQs", "Fr", and "ISO Store" (with a shopping cart icon). Below the menu is a breadcrumb trail: "Products > ISO Standards > By TC > TC 184 Automation systems and integration > SC 2". The main content area features a header for "TC 184/SC 2 - Robots and robotic devices" with a "print" icon. Below this is a section titled "Items to be displayed:" which contains a document icon and the text "ISO/NP 13482 Robots and robotic devices - Safety requirements - Non-medical personal care robot".

Legal: do we need new laws?

1. Legal status of robots with respect to Road Traffic
2. Liability in case of damages caused by robots
3. Insurance



Road Traffic Law

What is the legal status of service robots using public roads?

- *Article 8 of the Vienna Convention on Road Traffic (1968)* the convention states that each moving vehicle, including animals, shall have a driver

This article has been acknowledged, for instance, by:

- **Article n. 46 of the Italian Traffic Law:**
 - A vehicle is any machine of any kind circulating on roads driven by a human being



The case of Segway HT

- A kind of electric scooter
- In Barcelona is forbidden: “unclear what kind of vehicle is...”
- In Italy exempt from homologation because = to pedestrian
 - Circulate only in pedestrian areas, sidewalks, cycle tracks
 - Maximum speed depends of environment (6Km/h sidewalks, 20Km/h cycle tracks)
- In the US, Massachusetts, driver at least 16 years old and valid licence



Criminal and Civil Liability

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An Investigation on Legal Regulations for Robot Deployment in Urban Areas: A Focus on Italian Law

Pericle Salvini^{a,*}, Giancarlo Teti^b, Enza Spadoni^a, Emiliano Frediani^c,
Silvio Boccalatte^d, Luca Nocco^e, Barbara Mazzolai^f, Cecilia Laschi^a,
Giovanni Comandé^e, Emanuele Rossi^e, Paolo Carrozza^c and Paolo Dario^a

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2. Criminal and civil liability: In the Italian legal system a crime consists of two elements:

- *an objective element*: the crime (the result of an action or inaction)
- and a *subjective element*: the subject or actor of a crime.



Some Legal notions

- As to the *objective element*, the Italian Law states that in order to exist a crime must be the direct consequence of an action or inaction. In other words there must be a “causal link or direct connection”.
- As to the *subjective element*, the Law states:
 1. the agent must be *able to understand and act*.
 2. liability is only *personal*, which means that only human beings can be responsible for a crime.



Causal element

- **Definition:** direct connection between the behaviour of the agent and the expected event, even when *mediated* by a machine
- Autonomous robots: causal connection split into a two-phase structure:
 - Phase 1: event \longrightarrow robot activity;
 - Phase 2: robot activity \longrightarrow user/human behaviour.
- Such a structure implies an increased difficulty to prove that causal connection exists between the agent and the offence.



Subjective element

- Though autonomous, robots do not possess self-consciousness, consciousness nor will to act. Therefore, it is not possible to subject them to any kind of liability.
- However, even if possessing self-consciousness, consciousness and willingness to act, in order to be subject to liability, the Law (i.e. Constitutional Law) should be changed to make robots legal subjects, namely persons, that is human beings.



Robot Insurance

- Are insurance companies willing to taking the risk for ensuring robots working in urban areas?

Robot Insurance Policies

Home Robot Insurance Policies Robot Laborer Insurance Domestic Robot Insurance Contact Us

Recent Robot News

- The HRP-4C humanoid robot created by the National Institute of Advanced Industrial Science and Technology in Japan was publicly demonstrated on March 16, 2009.

Shopping for a Robot Insurance Policy?

You've come to the right place. Before you unwrap your newly delivered personal robot, make sure that you and your robot are fully protected. Personal robot insurance can protect you against domestic accidents or vandalism, and insures you against any liability that may result from your new robot. We work with the top insurers in the business and we can help you secure an affordable personal robot insurance quote.

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- Robot Laborer Insurance
- Domestic Robot Insurance
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The RoboLaw

Collaborative research project

Programme “Capacities” - Call ID “FP7-SCIENCE-IN-SOCIETY-2011-1” Topic: SiS.2011.1.1.1-3 Regulating emerging scientific and technological developments. **EU**

Financial Contribution: 1.497.966 EUR.

Duration: 24 Months.

Main research objectives:

1 To investigate the correlation between some new possibilities of regulations and technological developments, starting from the study (in terms of state of the art) of existing legal provisions, and aiming to adapt and create rules to emerging innovative technologies.

2 To study the interrelations, in this field, between technical, legal and moral norms, in order to define what could be the best balance between them, and what kind of rules are the most suitable to conciliate the transnational character of scientific and technological research (that makes it intrinsically “crossing-boundaries”) with the need of a common framework of values.

3 To analyze how regulations (in the different forms of hard and soft law) have been evolving up to now, disciplining technological innovations in the field of the so called “Biorobotics”.

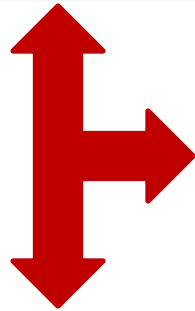
4 The most important outcome of the research will be the elaboration of a “White Book on Regulating Robotics”, containing some guidelines for the European Commission in the field of regulating emerging robotic technologies replying to the ethical concerns regarding its applications.



Project main actors

Supporting External Network

- 1) Inomed - Medizintechnik GmbH, (medical company);
- 2) Disabled Peoples International (DPI) DPI Europe is the European network of National Assemblies of Disabled People's Organizations;
- 3) Stanford Law School, The Center for Internet and Society, part of the Law, Science and Technology Program;
- 4) Masahiro Kobayashi, Japanese Lawyer



RoboLaw

External Advisory Board

- 1) Prof. Francesco Donato Busnelli: Professor Emeritus of Civil Law at the Scuola Superiore Sant'Anna of Pisa
- 2) Prof. José M. Galván Casas, Professor of Moral Teology Pontificia Università della Santa Croce, Roma, Italy
- 3) Prof. Martha J. Farah, director of Center for Cognitive Neuroscience, Uni Pennsylvania (US)
- 4) Prof. Stefano Rodotà: Professor Emeritus of Civil Law at University "La Sapienza" of Rome
- 5) Prof. Maxim Stamenov, Head of the Department of General and Applied Linguistics at IBL, Sofia University, Bulgaria.

1) Scuola Superiore Sant'Anna, Pisa, Italy
BioRobotics and DIRPOLIS Institutes

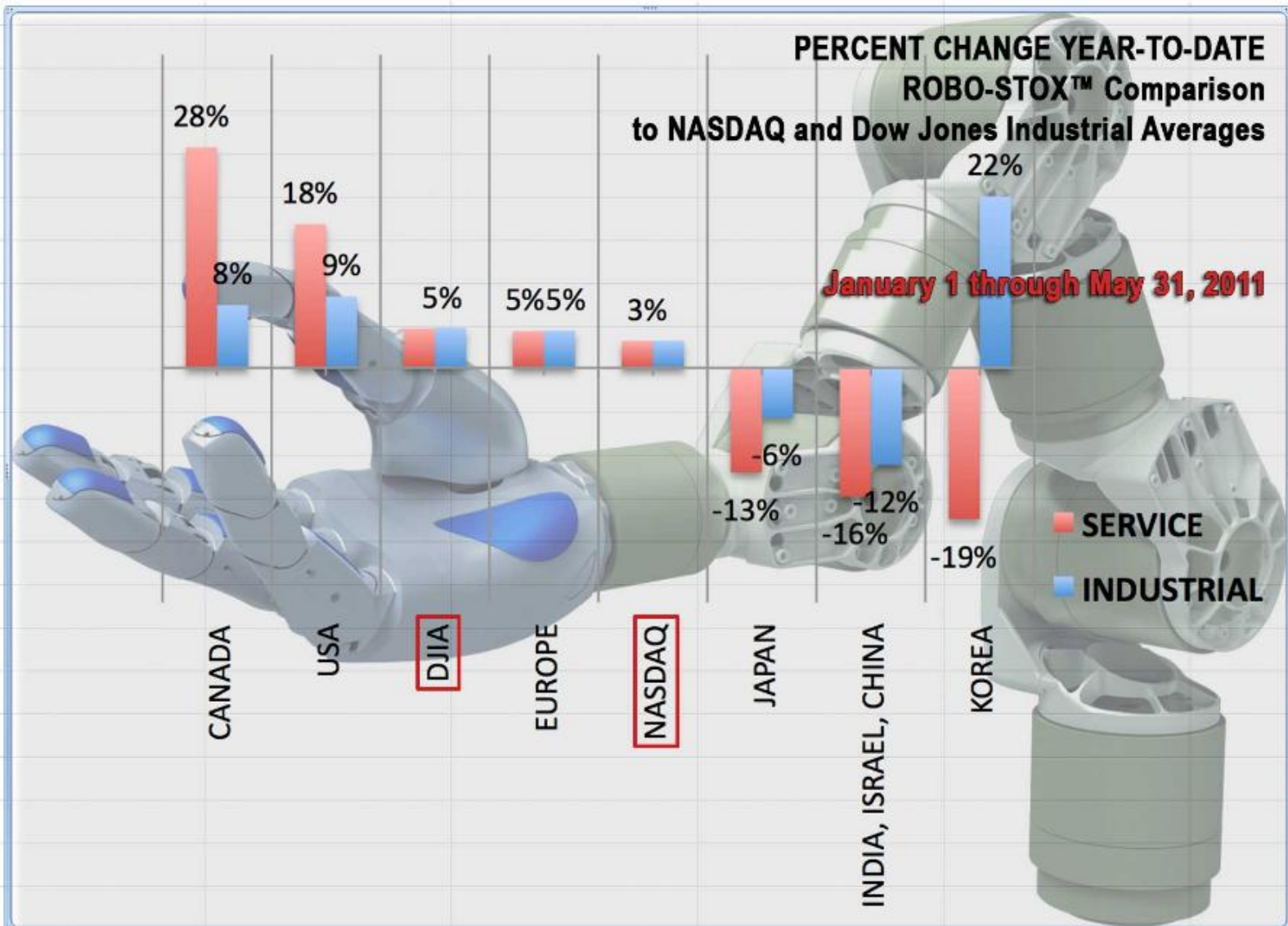
2) Tilburg University, the Netherlands
Tilburg Institute for Law, Technology, and Society

3) University of Reading, England (UK)
School of Systems Engineering

4) University of Humboldt, Germany
Department of Philosophy



Market





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Cost of technological components

“ Dear Sir,

Thank you for your email dated 17th July 2005.

Dyson has developed an autonomous vacuum cleaner that is powerful enough to clean efficiently and is sufficiently intelligent to take a methodical path around the room.

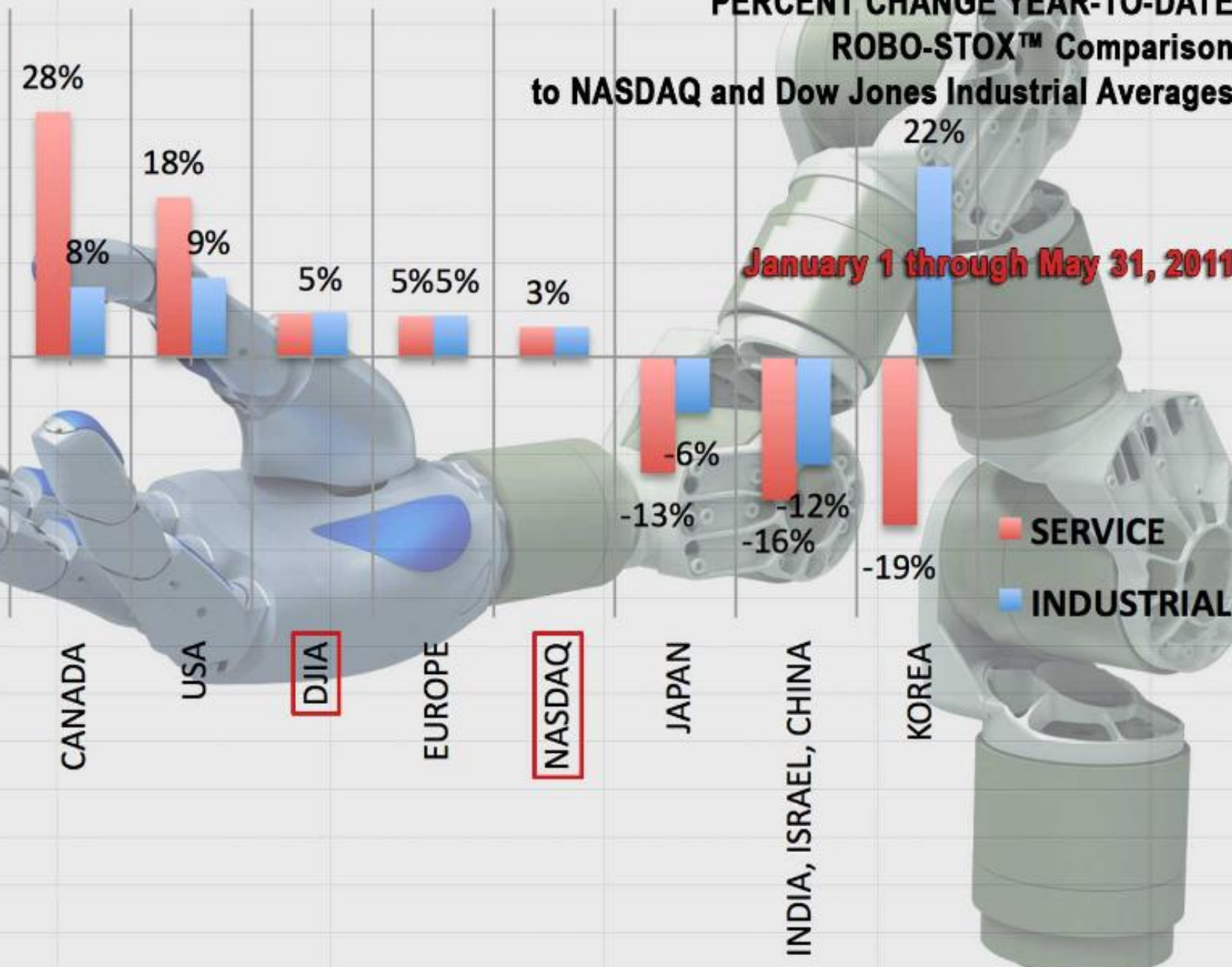
However, given current technologies, it is impossible to achieve high pick-up performance without pushing the cost of the machine above acceptable levels. Therefore Dyson will not be releasing this model at the present time.

Producing something that bounced aimlessly off the furniture and picked up very little dust would have been easy, but James Dyson insisted the Dyson DC06 robot should not only clean properly but should also guide itself more logically than a human would.”

*Letter by Daniel Whear
Customer Liaison of Dyson*

PERCENT CHANGE YEAR-TO-DATE ROBO-STOX™ Comparison to NASDAQ and Dow Jones Industrial Averages

January 1 through May 31, 2011



SERVICE
INDUSTRIAL

Social acceptance of robots



What is acceptability?

Definitions of acceptability:

*'the "willingness" of users to use a system or service in their particular context. Whilst this will partly depend on the perceived utility and objective usability it will also be influenced by other *intrinsic* and *extrinsic* factors like motivation, attitudes, knowledge, experience and *extrinsic factors* which arise from within the human, social and cultural environment of the user.'*

S. Richardson, 'Operationalising usability and acceptability: a methodological review. New methods in applied ergonomics', 1987

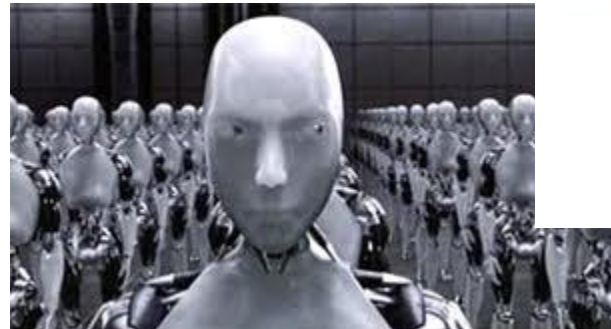
'the demonstrable willingness within a user group to employ information technology for the task it is designed to support'

A. Dillon, 'User acceptance of information technology', 2001



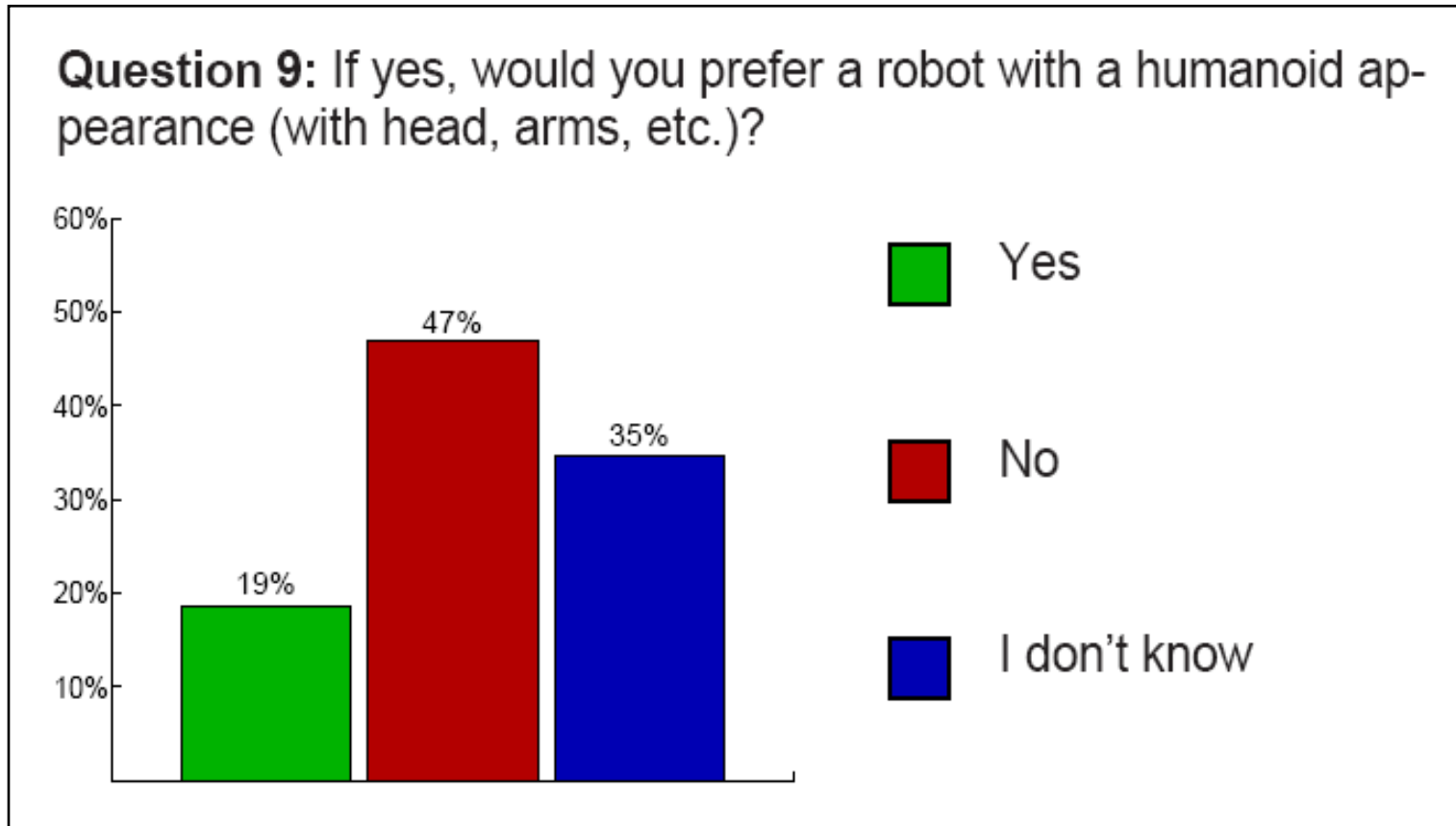
Intrinsic and Extrinsic factors

- What is the general attitude towards robotic technologies?
- Is the cultural and social environment ready to accept robotic services?



Question on robot appearance

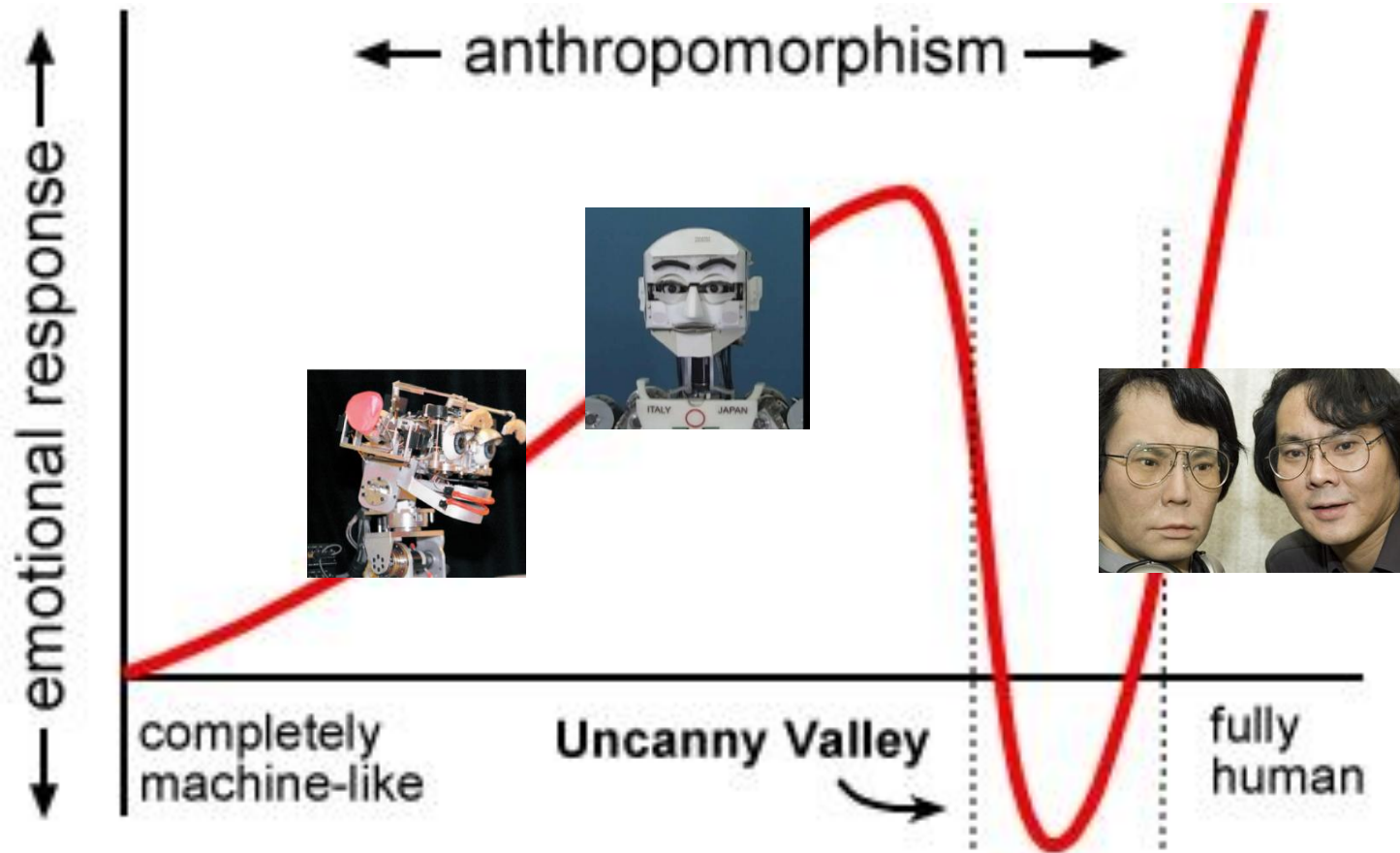
Results from a Survey at the Swiss National Exhibition Expo 2002



Cerqui D., Arras K.O., "Human Beings and Robots: Towards a Symbiosis? A 2000 People Survey", International Conference on Socio Political Informatics and Cybernetics (PISTA'03), Orlando, Florida, USA, 2003



The Uncanny Valley



Masahiro Mori 'The Uncanny Valley', *Energy*, 7(4), 1970.



Robots & “urban vandalism”



Three main remarks...:

1. How safe will be robots in urban environments?
2. What kinds of “attacks” could be targeted to robots?
3. And what would be the consequences?



How safe are service robots in urban environments? Bullying a Robot

P. Salvini, G. Ciaravella, W. Yu, G. Ferri, A. Manzi, B. Mazzolai, C. Laschi *Fellow, IEEE*, S. R. Oh, P. Dario *Fellow, IEEE*

Abstract— This paper describes and discusses the preliminary results of a behavioural study on robot social acceptability, which was carried out during a public demonstration in South Korea. Data was collected by means of direct observation of people behaviour during interaction with robots. The most interesting result to emerge is that of young people: they tended to react to the robots presence with extreme curiosity and, quite often, to treat them aggressively. In this paper the word *bullying* is used to describe any kind of

scenarios for service robots working in human-inhabited environments and, in some cases, to a few commercial products [14].

It is not too difficult, therefore, to image a not-to-distant future society in which robots will coexist with human beings in urban areas, providing citizens with services such as door-to-door garbage collection [6], information totem [7], street cleaning [6] human guidance [7] transportation of



Why *bullying* and not vandalism?

- ***Bullying***: ‘to hurt or frighten someone who is smaller or less powerful than you, often forcing them to do something they do not want to do’ (Cambridge Dictionary)
- Simulation of physical attacks usually targeted towards human beings and not objects (i.e. punching and kicking)

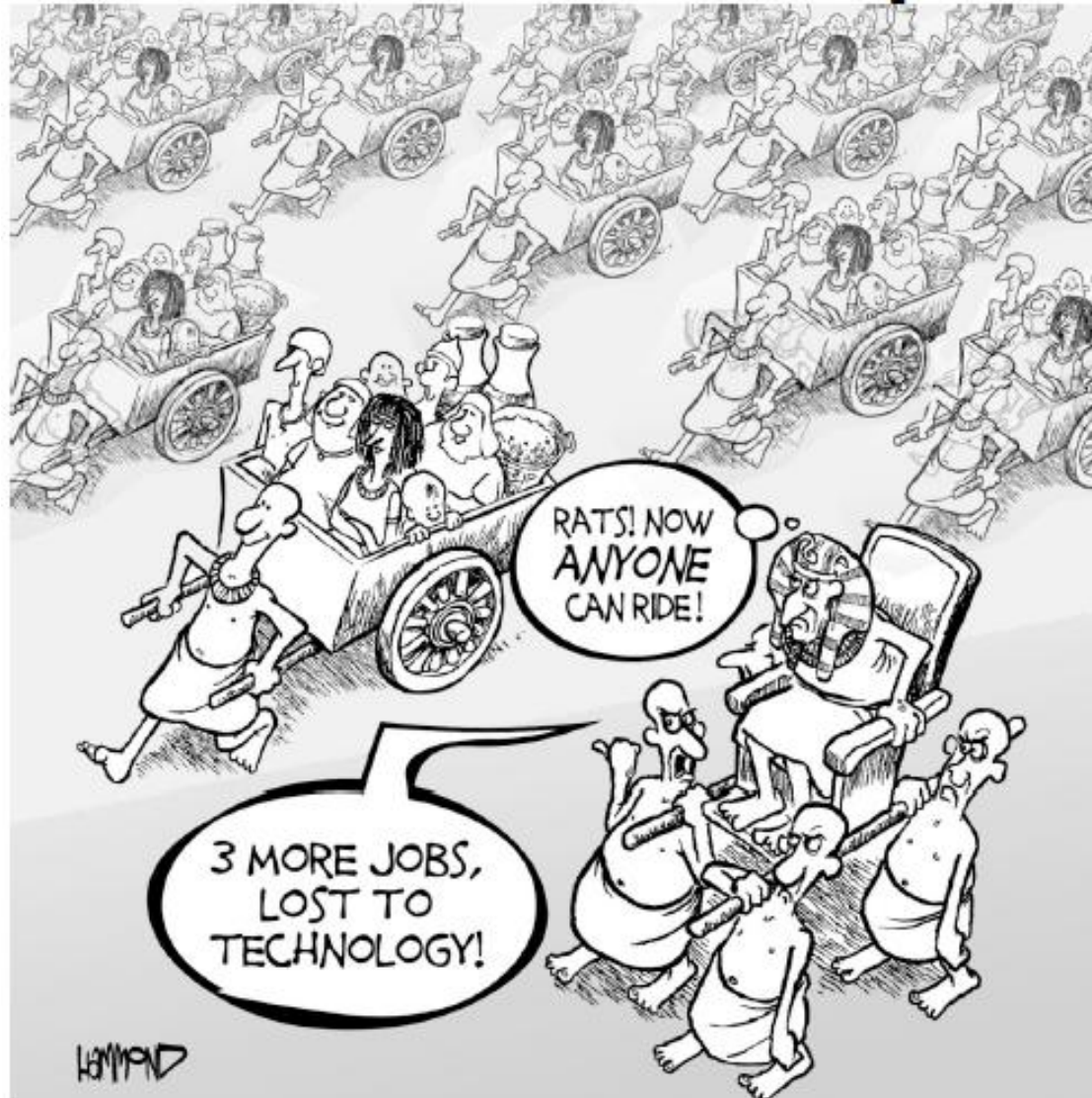


Why is relevant to tackle this phenomenon?

- Robot bullying can negatively affect:
 - People's and the robot safety
 - The quality of the service provided by the robot (e.g. delays, inability to carry out its task, etc.)



Robots and job market



A photograph of a busy street in a European city. The street is paved with cobblestones and has a yellow line marking. On the left, there are parked cars and a group of people, including a man in a grey suit and a man in a yellow shirt. In the center, a woman is pushing a stroller. On the right, a small green robot with a blue top and a white base is moving. The background shows multi-story buildings with balconies and windows. The text "Thank you for your attention." is overlaid in the center of the image.

Thank you for your attention.

Questions?

p.salvini@sssup.it