Autonomous Systems and Robot Companions: Paving the Way Towards the Establishment of a ‘Robolaw’ Framework in Europe

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- Conclusions
Robots are among us

- From industrial to service robotics
- Robots move closer to human beings
Robots are increasingly successful

More than 1 million operational industrial robots in the world, with a growth rate of 6% per year (Source: IFR)

Reliability of industrial robots:
Mean Time Before Failure = 40,000 hrs
Efficiency $\eta > 99.99875\%$ (Source: COMAU)

Around 5 millions service robots are sold annually
Service robots are one of the fastest growing markets (~14% per year)
Professional service robots account for 80% of sales value
Public attitudes towards robots

**Background:**

- Public perceptions of robots are often influenced by misconceptions and fears
- In order to improve the image of robots and to increase public acceptance, it is necessary to better understand public opinion about this technology

- **Representative survey in all 27 EU member states with 26,751 respondents taking part overall**

- **Fieldwork took place between February and March 2012**

*Courtesy: Björn Juretzki, Unit A2 – Robotics - DG Communications Networks, Content and Technology European Commission*
Majority of respondents have positive view of robots

QA4. Generally speaking, do you have a very positive, fairly positive, fairly negative or very negative view of robots?
• 70% of respondents think that robots steal people's jobs

• Opinion least widespread in Scandinavia and Central/South East Europe

• Strongest agreement in South West Europe
Overview of general attitudes towards robots

QA5. Please tell me to what extent you agree or disagree with each of the following statements about robots.

- Robots are a good thing for society, because they help people: 76% agree, 20% disagree, 4% don't know.
- Robots steal peoples' jobs: 70% agree, 27% disagree, 3% don't know.
- Robots are necessary as they can do jobs that are too hard or too dangerous for people: 88% agree, 10% disagree, 2% don't know.
- Robots are a form of technology that requires careful management: 91% agree, 6% disagree, 3% don't know.
- Widespread use of robots can boost job opportunities in the EU: 39% agree, 51% disagree, 10% don't know.
Respondents consider space exploration, manufacturing, military & security and search and rescue as priority application areas.

A major challenge for robotics research is to act **HERE**, in order to raise this low perception of usefulness of service robots.
Summary of Survey

- More open attitudes towards robots in Scandinavia and Eastern Europe, more negative views in Southern Europe
- Interest in science has a strong positive impact on how people perceive robots (and interest in science is declining across the EU)
- Image of robots as job killers still widespread (especially in big countries like DE, FR and ES)
- Once people get in touch with robots, their attitudes change and get more positive
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- Conclusions
The EU MOVAID Project (1994-1997)

Before MOVAID

Q: Can you imagine a robotic assistant?

- Yes: 10%
- No: 42%
- Don’t know: 48%

Techniques and tools

Questionnaires
Cross correlation of quantitative and qualitative data
Presentation and open discussion at meetings
User trials
Guidelines for design
Industrial exploitation
Administration uptake

LOOPS

Cultural Probes

Inspirational data
Community Portrait
Design concepts
S&T Requirements
Simulation/Prototype
Feed-back from users
Final product/service
The EU MOVAID Project (1994-1997)

Before MOVAID

Q: Can you imagine a robotic assistant?

User Trials

Yes 10%

Don’t know 48%

No 42%

64 users involved in user trials and demonstrations in 3 European countries
“Co-Pilot Mode”:
The MOVAID Robotic System (1994-1997)

The user is involved in task execution
(i.e. in object identification and localization)
Evaluation of the MOVAID prototype

User Trials

64 users involved in user trials and demonstrations in 3 European countries
The EU MOVAID Project (1994-1997)

Before MOVAID

Can you imagine a robotic assistant?

- Yes: 10%
- Don't know: 48%
- No: 42%

Would you like to have a robotic assistant?

- Yes: 43%
- Don't know: 36%
- No: 21%

User Trials

64 users involved in user trials and demonstrations in 3 European countries
Consolidating this experience and establishing “The RoboTown”

- **Peccioli** is a small town in Tuscany (Italy) composed of **squares and narrow streets** with slopes and ancient paving, **low populated** (about 5,000) and with a **high percentage of elderly citizens** (20% are over 65).
- Since 1995 the municipality of Peccioli has agreed with Scuola Superiore Sant’Anna and has supported the **R&D of innovative ICT-based solutions** in the field of **assistive and robotic technology** for elderly and disabled persons.
Main places of activities and field tests

- DomoCasa Living Lab
- Industrial Area
- Ghizzano Nursing Home
- Peccioli town center
- Social Services and Supervision
The town centre

The agreement with the municipality and institutions is crucial for availability of:

- all infrastructures involved in the experimentation
- technical, administrative and financial support
- legal authorizations and insurance
- the Peccioli social service centre

Applications and robotic services

- accompanying elderly people outdoor for walking, shopping, supporting and safety and for transporting goods in urban areas
- education and entertainment
- robots for management of urban hygiene by cleaning streets and transporting home garbage
Domocasa

- Living lab equipped with home automation system and facilities to favour experimental setting with real citizens and innovative technologies:
  - pervasive wireless sensor network and indoor robotic services

Applications and robotic services
- Companion robots for daily life assistance.
- Smart environments for assistance, monitoring, safety,…
- Tele-monitoring and internet-connected services.
- (Tele-)Rehabilitation
INFORMING, LISTENING and obtaining CONSENSUS: educational program with elementary, junior-high and high school students and teachers
Preliminary judgment about some services carried out by robots

- RS1) Cleaning streets autonomously
- RS2) Transporting domestic garbage
- RS3) Information service in urban areas
- RS4) Mini-bus transportation
- RS5) Guide in Museum
- RS6) Shopping bags transportation
- RS7) Educational activities and assistance for children
- RS8) Companion and assistance for elderly
- RS9) Best-practise tradition
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

www.dustbot.org
Designing the DustCart Robot

for garbage collection
The DustBot Project aimed at designing, developing and testing a system for improving the management of **urban hygiene**, based on a **network of autonomous and cooperating robots**, embedded in an **Ambient Intelligence infrastructure**.
The methodology used to design DustCart robot physical appearance

- To identify aesthetic guidelines using Quality Function Deployment (QFD) techniques
- To design “paper prototypes” using the guidelines identified
- To test paper prototypes with potential users by group interviews
- To use results to design a new version of the robot
Collaboration with citizens and administrators

- Public assemblies and other focused meetings
- User requirements analysis
Quality Function Deployment

- To find out characteristics that could be added to the DustCart’s main function as a robotic garbage collector
- To identify those users’ needs that could be correlated and satisfied by modifying the robot’s physical appearance.

<table>
<thead>
<tr>
<th>User’s needs</th>
<th>Robot’s characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not hurt me</td>
<td>5</td>
</tr>
<tr>
<td>Easy to use</td>
<td>5</td>
</tr>
<tr>
<td>Facilitating garbage disposal</td>
<td>4</td>
</tr>
<tr>
<td>Friendly</td>
<td>4</td>
</tr>
<tr>
<td>Efficient</td>
<td>4</td>
</tr>
<tr>
<td>Entertaining</td>
<td>4</td>
</tr>
<tr>
<td>Beautiful</td>
<td>4</td>
</tr>
<tr>
<td>Providing information</td>
<td>3</td>
</tr>
<tr>
<td>Contributing towards roads security</td>
<td>2</td>
</tr>
<tr>
<td>Not noisy</td>
<td>2</td>
</tr>
<tr>
<td>Feed-back and help on line</td>
<td>7</td>
</tr>
<tr>
<td>Touch-screen and GUI</td>
<td>8</td>
</tr>
<tr>
<td>Info on how to use the service: video ecc.</td>
<td>9</td>
</tr>
<tr>
<td>New material</td>
<td>23</td>
</tr>
<tr>
<td>Automatic lid opening</td>
<td>4</td>
</tr>
<tr>
<td>Icons</td>
<td>5</td>
</tr>
<tr>
<td>Level of autonomy</td>
<td>22</td>
</tr>
<tr>
<td>Expressiveness: sounds and lights signals</td>
<td>17</td>
</tr>
<tr>
<td>Biomorph appearance</td>
<td>15</td>
</tr>
<tr>
<td>Environmental info and road maps</td>
<td>10</td>
</tr>
<tr>
<td>Physical and large size buttons</td>
<td>6</td>
</tr>
<tr>
<td>Service request via telephone call</td>
<td>1</td>
</tr>
<tr>
<td>Idioms: colors and forms</td>
<td>16</td>
</tr>
<tr>
<td>Speed control</td>
<td>19</td>
</tr>
<tr>
<td>Separate waste collection</td>
<td>3</td>
</tr>
<tr>
<td>Obstacles avoidance</td>
<td>20</td>
</tr>
<tr>
<td>Light and acoustic signals system</td>
<td>21</td>
</tr>
<tr>
<td>Management of scheduling service</td>
<td>2</td>
</tr>
<tr>
<td>Tourist information</td>
<td>11</td>
</tr>
<tr>
<td>Multi-language communication</td>
<td>12</td>
</tr>
<tr>
<td>Washability</td>
<td>24</td>
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<tr>
<td>Educational vocal expressions</td>
<td>13</td>
</tr>
<tr>
<td>Friendly and pleasant appearance</td>
<td>14</td>
</tr>
<tr>
<td>Round and soft shapes</td>
<td>18</td>
</tr>
</tbody>
</table>
DustBot Design
Version A: Aesthetics

Design by Irene Mannari
Version B: Friendliness

Design by Irene Mannari
Version C: Affordance

Design by Irene Mannari
Design for acceptability

Perceived safety

Friendliness

Aesthetics

Aesthetics design patented

Affordance
The robots

DustClean

DustCart
The DustBot Demos

- Massa, Italy – 26 June 2009
- Bilbao, Spain – 15 September 2009
- Peccioli, Italy – 23 May 2009
- Örebro, Sweden – 25 July 2009
- Livorno, Italy – December 2009
- Pontedera, Italy – 09 May 2009
- Tokyo, Japan – 08 November 2009
- Osaka, Japan – 28-29 January 2009
- Bilbao, Spain – 2010
- Universal Expo 2010, Shanghai, China
- Techfest 2010, Mumbay, India
- Icheon, Republic of Korea
- Tomorrow City – 19-25 October 2009
- Tokyo, Japan
- Universal Expo 2010, Shanghai, China
- Icheon, Republic of Korea
- Tomorrow City – 19-25 October 2009
- Tokyo, Japan
- Universal Expo 2010, Shanghai, China
- Osaka, Japan – 28-29 January 2009
- Tokyo, Japan – 08 November 2009
- Osaka, Japan – 2010
The DustBot Passport

Osaka, Japan
28-29 January 2009

Bilbao, Spain
15 September 2009

Örebro, Sweden
25 July 2009

Pontedera, Italy
09 May 2009

Peccioli, Italy
23 May 2009

Massa, Italy
26 June 2009

Incheon, Republic of Korea
Tomorrow City
19-25 October 2009
DustCart@Shanghai Expo 2010
Italian Pavilion
Robots in Tuscany
Everybody like this robot

But is this enough?

No, we want service robots to be deployed in the real world and to become real products!
DustBot Exploitation Plan

DustBot Project

- DustBot system develop.
- DustBot demonstrations
- DustBot End-user analysis
- DustBot Deep Demo

Extensive testing (> 3 months) of the real service in real environments, with real end users under the supervision of real customers

- Industrial develop.
- Venture Capital
- Laws, Regulations, Insurance

bottleneck
DustBot testing site in Peccioli, the RoboTown
- from June 15 to August 7, 2010
- in the very heart of the town
- with real users: 24 families and 10 business activities
DustCart: main technical modifications for the field tests

DustBot Demonstrations
April-August 2009

DustBot testing
June-August 2010

- No Compass and GPS: only odometry and visual landmarks for localization
- New mobile base: 4 wheels to increase stability and deal with slopes
- New powerful batteries, up to 10 hours endurance
- New obstacle avoidance and path planning algorithms
DustBot Architecture

Control station
- system manager (AmI)
- robot management
- user interface

Modem
Call/SMS access point

user request

WiFi repeater
Our Design Strategy

Sharing intelligence between the robots and the environment

Clear advantages (performance and safety): for the robot, for the users, for the local administration….
DustBot Software Architecture

AmI – Ambient Intelligence
- call/sms management
- Robot management
- Users management
- robot activity scheduling
- Operator GUI

Robot Local Supervisor

Path Planning

Path following
Obstacle Avoidance

Robot Low Level Controller

Localization Module

Start Command Collection Point

Map

Beacon Position

Laser

Odometry
Objectives of Field Tests:
1) performances
2) usability
3) service cost
4) users' acceptance
DustBot testing results

- Total service time:
  - 47 days
  - 454 hours
- Total services: 402
- Total Km covered: 120.6
- Total Kg collected: 584.1

![Bar chart showing services for waste type]

- Paper: 137
- Plastic: 139
- Undiff: 126

![Bar chart showing Kg collected per waste type]

- Paper: 233.3
- Plastic: 94.5
- Undiff: 256.3
DustBot testing results

- Average duration of a collection service: 18 min
- Average waiting time from the call: 18 min
- Favorite time to call:
  - 9:00-12:00
  - 15:00-19:00

Number of services per day

Max: 18    Average: 8.55
DustBot testing results
User questionnaires

Are you satisfied with the DustBot service?
- Yes: 95%
- No: 5%

Did you have any difficulty using DustBot?
- Yes: 5%
- No: 95%

How do you judge the DustBot service? (Score from 0 to 10)
Average: 8.57
During the testing period did you use the DustBot service for the collection of...

<table>
<thead>
<tr>
<th>Always/often</th>
<th>Little/never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper 80.95%</td>
<td>Plastic 52.38%</td>
</tr>
<tr>
<td>76.19%</td>
<td>19.05%</td>
</tr>
</tbody>
</table>

What do you think are the shortcomings of the DustBot service?

- 3: Low capacity
- 6: traffic problem
- 2: slow service
- 2: None
- 3: Other
Urban robotics: are we ready to remove the fences to service robots?
Which implications for robot designers?

- *Technological challenges*: localisation, navigation, perception, obstacle avoidance, human-robot interaction issues…
- and challenges not solely related to engineering issues, such as…
  - *robot acceptance* at various levels: social, legal, and ethical
Classification of legal challenges

1. Administrative Law: the nature of the robot (i.e. what is a robot?)
2. Criminal Law: offences caused by the robot
3. Civil Law: offences caused by robot
Dealing with regulatory issues: dedicated *road signs*

‘Attention. Area subject to robotic testing. Yellow lane used by robots’.

‘Attention. Robot crossing. Yellow lane used by robots’.
Peccioli testing: the robot lane

- The **robot lane** is a special strip, in yellow colour, drawn on the left side of the roads. It was decided that the robot should travel inside the lane, on the left side, always in the same direction of cars. The “robot lane” was meant to avoid as much as possible interferences with car traffic. Since the robot was not able to give way to cars, three stops were devised in each road in order to avoid traffic congestion.
Robots insurance

- SSSA insurance policy (SAI company) covers any research activities, including demos, carried out with our prototypes by the institution personnel in any place of the world.

- However, due to the peculiar nature of Peccioli testing, the insurance company requested the payment of an additional insurance premium (850 € for 2 MONTHS).

- The robots were ensured against any liability resulting from their activities.

- The insurance did not cover damages to the robot.
Lessons learned

- The testing of DustBot system in Peccioli indicates that:
  - service robots can be deployed and make useful work in real urban settings
  - insurance companies take the risk at a very acceptable price
  - co-existence of current robots with real people for a reasonable long period of time (2 months continuous operation) is possible with no reciprocal damages
The “living lab” concept, and the emergence of AAL-Robotics CONVERGENCE

Control Center able to supervise and guarantee safety and security for people, robots and public spaces

The Robot-Era Project has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 288899
Experimentation in realistic scenarios
Experimentation with 16 elderly people 65+ (4 men and 12 women with 75 main age), including the 11 elderly of the design phase, in the Peccioli Living Lab, Italy (June 2012).
Ongoing research activities in Peccioli: the FP7 EU Robot-Era Project

Cooperating robots to assist elderly citizens from private (home) to social (the town square) life

The Robot-Era Project has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) under grant agreement num. 288899
So: people love real robots!
Da Vinci Robot and Intuitive Surgical at-a-glance

1840+ systems installed in 1450+ hospitals
1700+ employees

Installs by Country and Region

DaVinci Worldwide Installations (2010)

SOURCE: www.intuitivesurgical.com
...and people like robots that make useful things and that work really well

The “Secrets” of the DaVinci Robot Success: Accuracy, Dexterity, Intuitiveness

- Outstanding mechanical design
- Excellent optics (2D and 3D vision)
- Smart and friendly interfaces
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Robotics has made considerable progress

1973

WABOT-1	P2	KOBIAN	DB	CB	iCub	HRP-4C

WABIAN	ASIMO	HRP-2	ARMAR-III	Partner Robot	Hubo	ARMAR-IV

NAO	Justin	Lola	Robonaut	Twendy-one	Petman

Today
Question: is there a way to ACCELERATE this process and to develop robots that are truly:
- acceptable
- affordable
- sustainable
- dependable?

Achieving this goal is the objective of the FET-Flagship proposal ‘Robot Companions for Citizens’
The robotics bottleneck

Today, more functionality means more complexity, energy, computation, cost less controllability, efficiency, robustness, safety
Exploring a different paradigm: SIMPLIFICATION and INTEGRATION

less components
higher robustness
lower computation load
higher energy efficiency
higher adaptivity
higher dependability

Ultimately, lower COST
FET Flagships: a new and ambitious European initiative

The FET Flagship
“Robot Companions for Citizens”

Professor Paolo Dario
CA-RoboCom Project Coordinator
The BioRobotics Institute
Scuola Superiore Sant’Anna
Pisa, Italy
The FET Flagship initiatives

- **Ambition:** the goal should be a breakthrough, involving major challenges in S&T, and require a large federated effort and strong leadership

- **Impact:** to yield a leverage effect in terms of research, funding and economic activity affecting in the long run European competitiveness, industry, society, governance and sustainability

- **Integration:** resources and research agendas from different disciplines would need to work together toward the Flagship goal

- **Plausibility:** the different areas of research should be at appropriate level to be assembled into a roadmap with reasonable milestones
"We must provide citizens the greatest benefit for the best value"

INTERVIEW BY DANIEL SARAGA

Solving society’s toughest challenges requires massive research funding, says European Commissioner Neelie Kroes.

Two European research consortia will receive €1 billion each within the Flagships program, an initiative launched by Neelie Kroes, European Commissioner for the Digital Agenda. The former Dutch politician explains why large-scale research matters.

The race for €1,000,000,000

BY DANIEL SARAGA

With its Flagship Initiatives, the European Union has created a unique competition that will extend the horizons of science. Six research projects are now fighting for the big prize.

One hundred million euros every year for 10 years. What scientist wouldn’t drool at the prospect of such generous support for his pet project? But the offer is no dream. It’s what the European Union has put on the table through its Flagship Initiatives – large-scale, science-driven, research delivering on their promises, which range from predicting economic and societal crises to developing robots to accompany us in our daily lives (see box). The EU wanted revolutionary projects, and the scientists delivered with enthusiasm: their objectives are extremely to raise the level of European research in the face of rising Asian scientific powerhouses, notably India and Korea. Kafatos worries, however, that the money will be granted at the expense of direct grants to researchers. "It is critical that individual grants from the
S&T Vision, Objectives and Priorities

RCC FET Flagship as a bridge between science and sustainable welfare
Robot Companions are an enabling technology for sustainable welfare

**Private environments**
- Personal assistance for physical and psychological welfare

**Economic environments**
- Affordable economic and social welfare
- Ageing of population (at home, at work, in the society…)

**Physical environments**
- Conserving and monitoring the planet
- Tackling natural and man-made disasters

**Urban environments**
- Growing urban centers
- Maintaining the quality of life at urban scale
RoboCom will pursue systematically invention and “disruptive” innovation

- NO well defined technical ROADMAPS, but a clear objective
- Partly unpredictable (but unavoidable) “quantum leaps” of scientific and technological advancements
The RoboCom FET Flagship bridge to link «Excellent Science» and «Societal Impact»

RoboCom: From New Scientific Knowledge to New Engineering Principles
A whole new Robotics

We need *simplification mechanisms and new materials, fabrication technologies and energy forms*

We want to tap
the biggest and most advanced treasure of engineering solutions

- Studying natural organisms and understanding what makes them so smart and efficient
- Studying things only living organisms can do, and how they do it
SCIENTIFIC PILLAR 1: SIMPLEXITY

- **Simplexity** comprises a collection of solutions (simplification mechanisms) that can be found in living organisms.
- An approach to **cope with the real world** and to **coordinate a large amount of motor and sensory data**.

Morphological computation designates the idea that part of the computation required for particular behaviors can be performed by the body, incorporated into the morphological and material characteristics of the agent. The brain itself, as part of the body, also applies morphological design principles to achieve its computational tasks.

→ distinction: control - to-be-controlled falls apart

EXAMPLE OF MORPHOLOGICAL COMPUTATION: EMERGING BEHAVIOURS

Dynamical properties and mechanical feedbacks lead to stable emergent behaviors: Adaptation in small biomimetic robots

SCIENTIFIC PILLAR 3: SENTIENCE

- Sentience is integration across perception, affect, cognition and action
- Sentience creates a coherent scene in which action can be interpreted, predicted, planned, generated and communicated

Sentience is a system level feature that requires a system level theory if you want to build it (intense cooperation with neuroscience)

Friston (2010) *Nature Rev Neuro*
SCIENTIFIC PILLAR 4: MULTIFUNCTIONAL NANOMATERIALS AND ENERGY

- This pillar will enable a **brand new approach** to the fabrication of RCs endowed with **biomechanical features** and provide new multi-functional micro- and nano-fabricated materials for sensing, actuation, computation, communication, energy, exo- and endoskeletons, power storage, harvesting and generation systems, etc.

- The goal is to realize RCs with less components, higher robustness, higher compliance, lower computational load, higher energy efficiency, higher adaptability, higher dependability and ultimately lower cost.
All efforts of RoboCom will be inspired by the expectations and needs and will aim at fulfilling the requirements and concerns of Citizens and Society.

Citizens will ask such questions as:

- Robots will replace people – Robot Companions will work for welfare instead of maximizing profits.
- It is unethical to build a robot with emotions or sentience.
- Robots will develop their own dynamic evolution.
- Robots will dominate me.
- Dominance of technology on mankind.

- RoboCom actively integrates all stakeholders, including society, ethicists and legal experts to directly address these concerns.
The Society pillar will provide a driving force by:

- **Understanding societal needs, attitudes, and expectations** in order to make RCs truly useful and acceptable for all citizens.

- **Developing ethical, legal and societal principles** to steer scientific and technological research and robots applications.

- **Designing educational programmes** to train a new generation of RCC scientists and engineers capable of turning bio-inspiration into engineering solutions and dealing with ethical, social and legal issues.

- **Involving policy makers and stakeholders** to create the proper framework for RCs deployment and industry to realize safe, dependable, sustainable, and low-cost robotic solutions and develop new robotics-based markets and labour opportunities.
Our vision

- Science grounded robotics
- Sentience
- Multifunctional nanomaterials and energy
- Simplexity
- Morphological computation
- New engineering
- New science
- New industry
- New markets
- New jobs
- Robot Housekeeper
- Robot Rescuer
- Others...

Society

Multifunctional nanomaterials and energy

Morphological computation

New engineering

New science

New industry

New markets

New jobs

Robot Housekeeper

Robot Rescuer

Others...

Multifunctional nanomaterials and energy
Concepts of what RCC will develop and deliver (intermediate and final results)
RoboCom Consortium

CA-RoboCom:
10 partners from 8 countries
- 3 RoboCom plenary meetings with more than 200 participants
- 23 Community working group meetings
- 22 Meetings with stakeholders, decision makers and/or scientific communities

RoboCom Consortium
- 73 core partners from 24 Member States
- 109 Leaders and co-Leaders from the 73 institutions

Enlargement of the RoboCom research community with Open Calls to involve more than 240 - 280 partners

Geographical distribution of RoboCom Core partners
146 Endorsement letters from 30 Countries

- 85 academia, research institutes and foundations
- 33 funding agencies (Central and regional governments)
- 28 industries
- 122 letters from EU zone (Member States+Associate Countries)
- 24 from Global Partners
  - China (8)
  - Japan (4)
  - USA (6)
  - Brasil (1)
  - United Arab Emirates (1)
  - Australia (1)
  - Korea (1)
  - Singapore (1)
  - Taiwan (1)
  - New Zealand (1)
RCC Worldwide view:
a European Flagship leading a global fleet and alliances
Global view of possible alliances
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Challenges to be overcome
- Better science and better technologies
- Social, ethical and legal issues

Autonomy and Law

Conclusions
Social acceptance of robots
Bullying Robots
The study site

Sunken Plaza (Incheon, Republic of South Korea)

Operative scenario:
Piero introduces DustCart to passersby by vocal messages. Piero describes DustCart functions and invites people attending to trash their rubbish by using DustCart

Global Fair & Festival held from Aug. 8 to Oct. 25 2009 in Sunken Plaza,, Incheon

A collaborative research between SSSA, ETRI and KAIST
From playing to bullying robots the step is short

• Improper behaviour originated out of curiosity:
  – Exploring the robot
  – Testing the robot’s limits (e.g. covering the robot’s camera, standing in front of the robot, etc. ...)
  – Playing with the robot (e.g. pushing repeatedly the robot bumpers to trigger vocal messages)
A cross cultural phenomenon

Credits: courtesy of ATR Intelligent Robotics and Communication Laboratories
The DustBot system tested in Peccioli (Italy)
After 16 years of continuous collaboration, at RoboTown this is a well established methodology

- Citizens know us and are confident in our attention and skill
- Administrators are believers and supportive
- The user-centered methodology can be smoothly adopted for different applications, exported and also offered to external users
Peccioli, the RoboTown will be a RIF (Robotics Innovation Facility) in the new FP7 CH2 Project ECHORD++ (2013-2018)

- Offering permanent test-bed for industry-university joint experiments and tests
- Performance evaluation
- Standards
- Legal requirements and constraints
- Insurance
- User satisfaction
- Market analysis
### Scenarios and research foci

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The Legal Challenges

- Two main challenges depending on:
  - what robots are
  - what robots can do
The RoboLaw Project

RoboLaw
Regulating Emerging Robotic Technologies in Europe. Robotics Facing Law and Ethics

Project Information

Co-ordinator:
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Start date: March 1st, 2012
Duration: 24 months
Total cost: € 1,890,491.20
EU contribution: € 1,497,966.00
Grant Agreement No.: 289092
Call: SiS 2011.1.1.1-3

The RoboLaw project involves 4 partners from 4 European countries: Italy, Netherlands, and United Kingdom and Germany

The most important outcome of the research will consist of a White Paper on Regulating Robotics, containing guidelines and suggestions for the European Commission in the field of regulating emerging robotic technologies, in response 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

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 Theology 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
Project main objectives

Integration of technology into society: Governance patterns
Studying the features of emerging regulatory tools, including soft law instruments such as ethical rules, technical standards and codes of conduct

Roadmapping Robolaw
Describing the state of the art of the existing regulations pertaining to robotics in a comparative perspective

Elaborating a taxonomy of robotics
Clarifying the differences in terms of language between the various types of technologies being considered

Philosophical, anthropological, sociological consequences arising from the use of emerging robotic technologies for human enhancement
Investigating the relationship between future technologies, human values and society

Policy recommendations defining guidelines and suggestions on regulating Robotics
Elaborating “Guidelines on Regulating Robotics” for the European Commission
Autonomy and Law

- The current legal systems are not ready to deal with robots that exhibit autonomous behaviours in human-inhabited environments
  - Legal subjectivity and of legal acts by robots
What is autonomy?

- A definition of autonomous robot:
  - 'the capacity to operate in the real-world environment without any form of external control, once the machine is activated and at least in some areas of operation, for extended periods of time' [Lin et al, 2008].
Robots and Legal capacity

- It is not a matter of ontology
- But a practical and functional solution
  - Ability to perform legal transactions (entering into a contract)
Legal categories for robots

 Responsible entity

 Person

 Agency

 Children

 Diminished capacity

 Dangerous animals

 Product liability

 Robot as property

 FRANKENSTEIN UNBOUND
 Towards a legal definition of Artificial Intelligence

 Sam N. Lehman-Wilzig

 FUTURES December 1981
Legal Issues

• Main cases of differentiation between person and subject in the European Member State Law:
  – unrecognized organizations and some kind of corporations without legal personality;
  – conceived baby before birth;
  – animals.

• Assessing the possibility to extend some of their *rationales* to the recognition of robots’ subjectivity.
What about robots?

- Should the recognition of subjectivity derive from the “legal environment” in which autonomous robots are going to act?
Three possible approaches

1) considering robots as a sort of extension of their users’ will and physical body, so that any act they execute is directly referable to the former
2) awarding robots full capacity
3) acknowledging companion robots as autonomous agents, endowed with the status of subjects, but capable of entering into transactions under certain constraints.
   - The reduced capacity of minors or of the mentally impaired, known and disciplined in the current legal systems, could be taken as a model for regulation.
Legal capacity and the issue of liability for damages

- It is necessary to consider whether:
  - the existing rules about producer’s liability or liability deriving from the ownership or possession of things apply;
  - or the technology is so highly developed and advanced, provided with a certain degree of decision-making ability, that the rationale underlying those sets of rules cannot operate.

- And it is necessary to distinguish between:
  - Traditional machines, that can be designed and manufactured so that their behaviour will be predetermined or predictable by the constructor and afterwards mastered by their user;
  - Sophisticated robots, that do not correspond to this archetype.
A possible model rule

- The basic structure of most legal regimes regarding injuries caused by minors and incompetent persons could be taken as a model rule.

- These cases share some common features:
  - the limited capacity of the agent, not sufficient to held him fully responsible for the damages he has produced;
  - but also an independence of action, more or less substantial, that the agent exhibits and that accounts, at the same time, for the possibility of the guardian to be exonerated by demonstrating not to be at fault (or to have adopted every reasonable precaution in order to avoid accidents).
Privacy

- A third domain of investigation concerns privacy and data protection. Some robots will process personal data (e.g. visual imagery by surveillance drones, personal data by domestic and medical robots) and hence enter the remit of data protection.
In the loop, on the loop or out of the loop?

- Legal regulations should be used to restrict autonomy in specific circumstances and for specific actions:
  - for instance when robots are engaging with humans, authorisations may be asked before making a decision
  - Only certain actions can be carried out autonomously
- Advancements in the performances and safety of autonomous robots systems will be determinant
- Ethical and cultural issues will also play a role in reducing resistances towards the application of autonomy
Conclusions (Part 1)

- A revolution has occurred with the advent of the web, the cloud, the social networks, and the widespread introduction of smart personal and portable devices: they are the real personal assistants.
- Robots are not portable, and they must do more than communicate. However, they must be integrated and be part of the network around us.
- People are ready and willing to accept and use robots, provided that they are useful, affordable, sustainable, dependable and provided that they do real and heavy work for us.
- A solution: robots as supervised systems (operation according to the flight-control model).
- This will occur anyhow. However, the progress and deployment of companion robots can be accelerated by rethinking the way robots are designed, and through a global effort in this direction.

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Conclusions (Part 2)

- It is important and timely to get robots out the lab
- The citizens want and are ready to test advanced services
- Important lessons learned on design and acceptability of service robots in real settings
- Local administrations increasingly committed and willing to make service robotics a Flagship
- Companies eager to enter the market of service robots
- A permanent open infrastructure will be ready soon to test novel service robots with real users (ECHORD++ Project, 2013-2018)
- Legal and insurance issues can be addressed in specific and limited situations
- Investigations and actions urgently needed to formalize and systematize such work

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