The importance of close collaboration between academia and industry — Successful examples from recent years and future challenges

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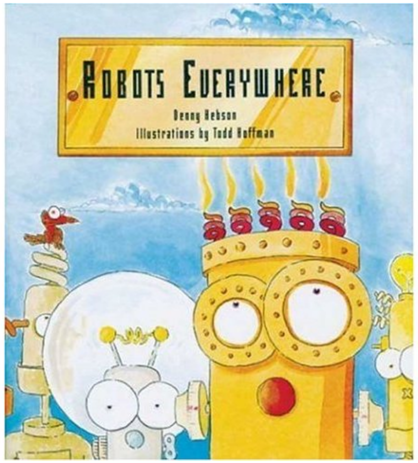
Robots !!!

- Robots on Mars and in oceans, in hospitals and factories, in schools and homes
- Robots fighting fires, making goods and products, saving time and lives
- Robots today are making a considerable impact on many aspects of modern life, from industrial manufacturing to healthcare, transportation, and exploration of the deep space and sea
- Robots tomorrow will be as pervasive and personal as today's personal computers
- The dream to create machines that are skilled and intelligent has been part of humanity from the beginning of time. This dream is now becoming part of our world’s striking reality

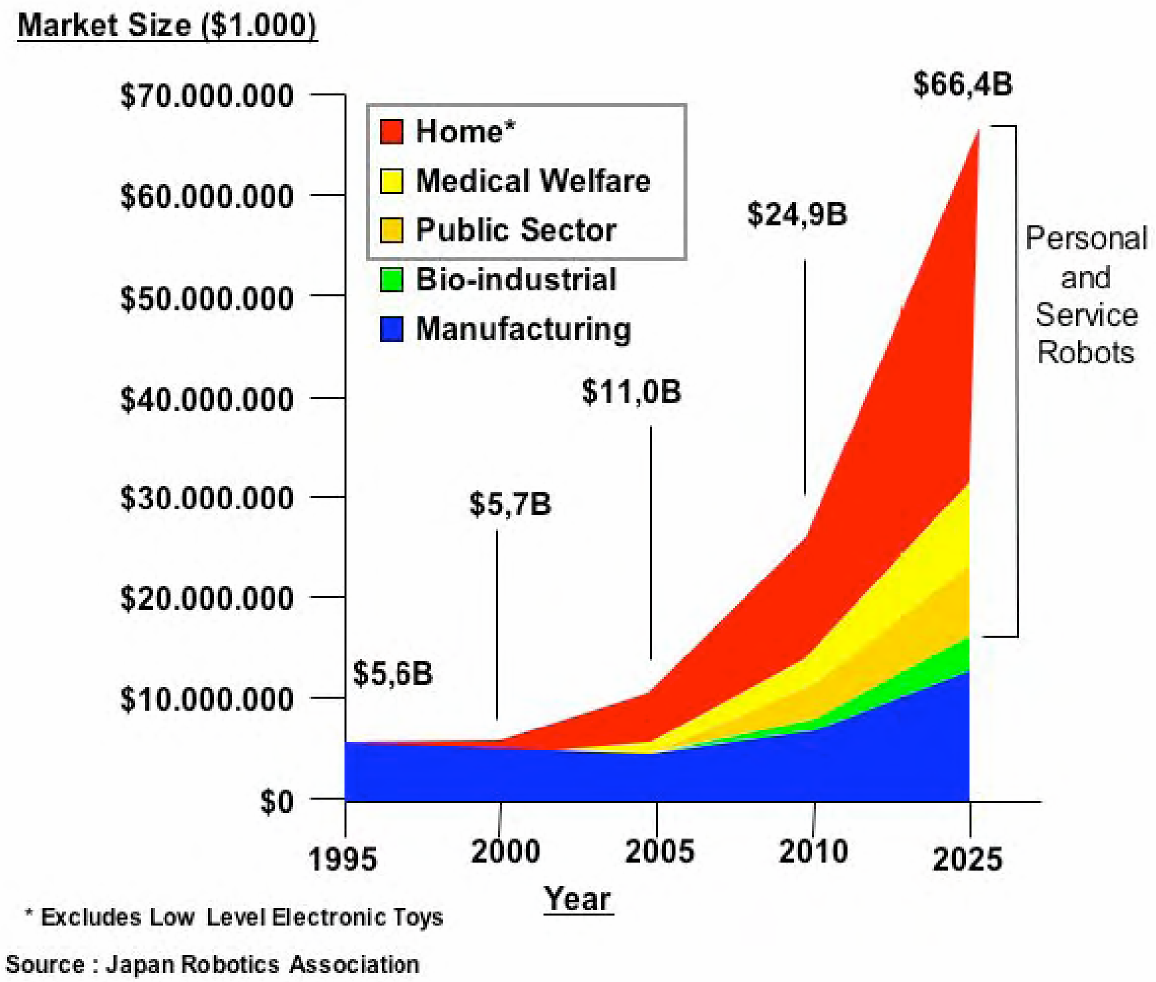


Well-Assessed Areas

Industry	Field	Service
		
Automotive Chemical Electronics Food	Aerial Space Underwater Search and rescue	Domestic Edutainment Rehabilitation Medical

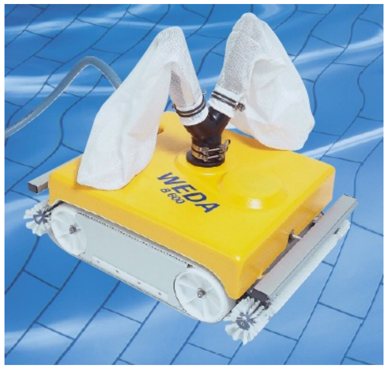
Autonomy

Interesting Economics



Service Robots

- Robots find applications in “4D tasks”
  - Dull
  - Dangerous
  - Dirty
  - Dumb
- Service robots
  - Health care
  - Entertainment
  - Security
  - Personal assistance
  - Construction
  - Cleaning



Personal Robots

- Service robots that are consumer products
  - Education/hobbyist robots
  - Entertainment robots
  - Smart toys
  - Robotics pets
  - Automated home
  - Partner robots

- NSF/WTEC report across different fields and continents

Basic	U.S.	Europe	Japan/Korea
Mobility	**	***	***
Perception	****	***	***
Autonomy	****	***	***
HRI	***	***	***
Manipulation	**	**	**
Applications			
Industrial	*	**	***
Service	**	****	***
Personal	****	**	****

Research Agenda World-Wide

- U.S.
  - First industrial robots designed and built
  - Matured elsewhere, in spite of entrepreneurial culture
  - Most robotics research is funded through military, space and security programs
- Japan
  - Strategy for creating new industries includes robotics as one of the seven areas of emphasis
  - Close collaboration between government, academia and industry
  - Robot manufacturers:
    - can rely on public opinion that robots are widely accepted by society — they are seen as useful helpers (co-workers to their human counterparts), not as job-killers
    - they have a strong home market with the highest density of robots
    - cover a larger spectrum of robots
    - are typically part of huge vertically integrated industrial conglomerates that can build up massive R&D and commercial power

Research Agenda World-Wide [cont'd]

- Korea
  - Of the 10 next generation growth engines, robotics is one of them
  - Close collaboration between government, academia and industry
- Europe
  - Robotics industry is strong, but still quite fragmented and dispersed
  - Industry observers agree on the following global trends in the industry:
    - Due to saturation in the classical (automotive) markets, all major manufacturers will need to identify new areas to maintain growth
    - The rapid development in technology areas that are the basis for robotics — mechatronics, computers, sensors, programming, human interfaces — bears huge potential for totally new application scenarios. Clearly, these developments may also result in a dramatic re-distribution of the market share of robot manufacturers in future application scenarios

European Challenge

- Competition between Japan and Europe will continue to increase
  - Neither will win out on cost – technology will be the most decisive factor which will determine who will lead the industry in the future
- Currently, the overall situation in Europe is as follows
  - On the industrial side, there are:
    - global players in the manufacturing robot sector (classical arms and their control)
    - a number of SMEs which specialise in the design of mobile platforms and a number of software suppliers
    - many system integrators and consultants for programming industrial robots
  - On the research side, there are:
    - large and powerful institutes for applied research in robotics that work in, more or less, close co-operation with their local industry (an ever increasing number of university institutes; public research institutions like INRIA, Fraunhofer, IIT, Helmholtz; and institutes that are directly or indirectly funded by private foundations)

Background

- Europe has a very strong robot industry and there is significant world-class research potential and technological knowledge spread around
- However, finding common ground between Robot Manufacturers (RM) and Research Institutions (RI = universities, research centres and institutes), especially when it comes to setting future direction of robotics research, has been difficult in the past
- For this reason, it would be highly advantageous to strengthen European technology profile by creating new opportunities for know-how transfer between RI and RM
  - This should be done both for developments in classical industrial robotics and for technologies that will be required, e.g., for future intelligent machines in "cognitive factory" scenarios

Gap Between RI and RM

- Implementing this know-how transfer in concrete measures and actions will be a great challenge
- It is important to recognise that there has always been excellent R&D performed at both RM and RI, and that cooperation has taken place between privileged RM and RI
- However, there is an "obvious and significant discrepancy between the state of the art in robotics research vs. actual utilized technology. If direct contact between researchers (who usually write papers) and industrial engineers (who normally do not read papers) is to be promoted, then results have to be put in a true industrial perspective"
- So, the main question is: how can effective and efficient RI/RM cooperation be achieved?

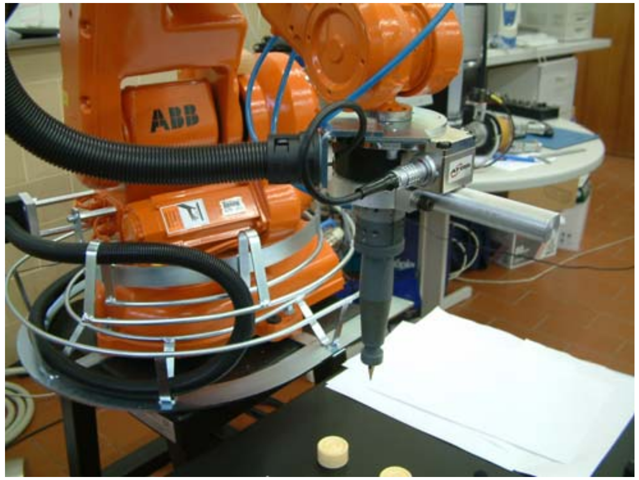
Analysis of Past

- Past cooperation became technology transfer success story only when:
  - a concrete problem was relevant to RM and scientifically interesting to RI
  - the specific competences of both sides were really challenged
  - RM provided state of the art equipment so that RI's work was carried out on RM's equipment – and results could be demonstrated on their robots
- Cooperation was geared towards the development of:
  - enabling technologies ("How can we develop a sensor for the automatic analysis of milk for our new milking robot?")
  - application scenarios ("Can we use robot X in combination with component Y for our customer Z, who has a handling problem with his wafer transport chain and is now considering the use of robots")
  - feasibility demonstrations ("Would it be possible to use proximity sensor X with robot Y in this envisioned human-robot co-worker setting, and how? Can you develop the principles of operation and build a realistic prototype in co-operation with our R&D department?")

- 7-axis Light Weight Robot
  - Designed and built @ DLR, a KUKA product now
  - Weighs 15 Kg and lifts up to 14 Kg
  - Easy to be moved around
  - Innovative joints and actuator solutions
  - Gravity compensation
  - Force control with joint and wrist F/T sensors
  - Safe human-robot interaction (SME robotic cell)
  - Service and space robotics applications
  - Other features, like interfaces with popular packages (Microsoft Robotics Studio)
  - Used in Justin humanoid manipulator @ DLR (2 LWR + torso + sensorized head)
  - Mounted on mobile base, on display @ Automatica 2008

A Few Success Stories [cont'd]

- Force control system
  - Developed @ ABB Corporate Research in cooperation with several Universities and European Projects
  - Motion instructions enabled with force control using F/T sensor
  - Innovative and agile product, helps faster and more efficient programming
  - Promises to be standard very soon

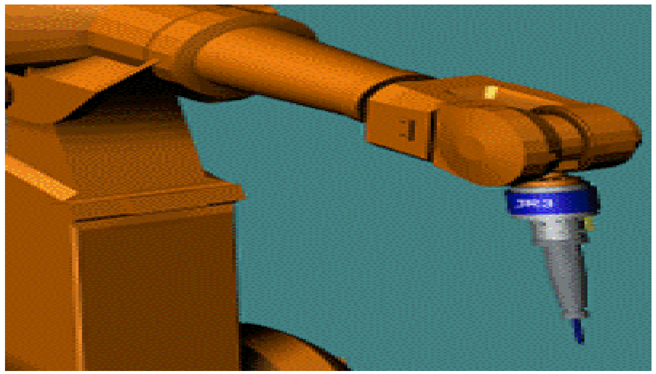


- Automatic identification of robot payloads
  - Algorithms developed @ UniNa and implemented in COMAU C4G controller
  - Better dynamic performance, especially during fast motion
  - Collision detection algorithms based on measurements of internal variables
  - Real-time motion trajectory planning satisfying user and dynamic constraints

A Few Success Stories [cont'd]

- Parallel kinematic machine
  - Modular and scalable desktop robot designed @ LundTech, an ABB product now
  - Professional ball joints and drive technology
  - Down-sized for classroom use and low cost
  - Open source real-time Java control software
  - Interfaces to Microsoft Robotics Studio
  - On display @ Automatica 2008

- Force/torque sensors
  - DLR compliant F/T sensor, used for medical and industrial applications, a SHUNCK product now
  - SMErobot F/T sensor, designed to meet industrial and price requirements, on display @ Automatica 2008
  - Strong link between JR3 and UCoimbra resulting in several developments in terms of software, interfaces and robot controller solutions



Lessons Learned

- Cooperation resulted in the recognition of new problem areas on the part of RI, which in turn encouraged creative thinking in the direction of new potential "neighbouring" applications on the part of RM (market-orientation vs. long-term orientation)
- This continued result-oriented dialogue also led to build up of trust between RI and RM, which opened up lines of communication at more confidential levels (protection of IPR vs. public sharing)
- This step-by-step interaction and exchange of ideas is the most promising path to meet the ever-changing demands of RM on one hand and fulfill the problem-solving drive of research of RI on the other hand (practical product development vs. 'visionary' methodology/theory)
- Abstracting from concrete examples, in order to fuel knowledge exchange between RI and RM, the greatest advantages are expected from an "emulation" of the important and successful aspects that made the previous cooperation between RM and RI successful

Future Challenges

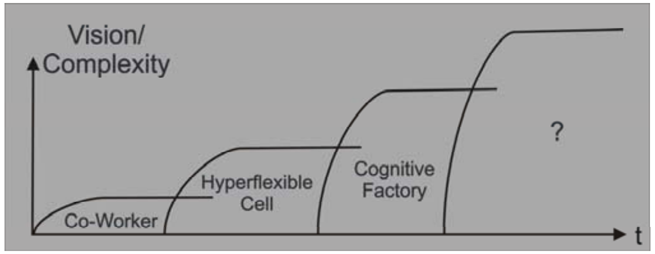
- Need for a radically new and unique strategy to streamline successful bi-directional know-how and technology exchange, which would truly be "open" to those entrepreneurial RI willing to carry out challenging "robotics development" in cooperation with RM, and ultimately increasing European competitiveness in the field
- Provide incentives for both sides, RM and RI, in order to systematically extend such successful cooperation patterns
  - RM can develop new products in short time frame with help of RI
  - RI can synchronise their research vision with RM's needs
  - This will include those RM and RI, who have not had preferred mutual access and will enable partners with well-established cooperation to invest more
  - It is very appealing to RM and RI to carry out small-size joint projects (experiments) solving concrete problems

RI/RM Cooperation

- Experiments, with clearly defined goals in terms of quantifiable technological advancement, to be targeted toward:
  - joint enabling technology development (develop new robots, components, network, etc. based on bi-directional exchange of knowledge)
  - application development (use robots/components in new areas and scenarios)
  - feasibility demonstration (show that prototypes can actually be deployed in classical industrial settings, e.g., if a factory's workflow is adapted) — promising and most interesting for system integrators and smaller industrial users

Challenging Scenarios

- Scenarios are to be conceived to provide guidance to bridge gap between state-of-art and ground-breaking research. They should:
  - Encourage RM and RI to identify and work together on emerging technologies
  - Take advantage of results achieved in previous European projects
  - Help to assess the actual progress achieved in the experiments
- The foreseen scenarios are:
  - Human-robot co-worker
  - Hyper-flexible cell
  - Cognitive factory



- The first scenario — the human-robot co-worker — is rooted directly in today's state of the art (current major challenge in industry-related robotics)
- The follow-up scenarios are even more ambitious and future-oriented
  - They are based on one another, using directly the technologies developed in the preceding one
  - They increase in complexity and require incorporation of completely new ideas

Awarding Excellence

- IEEE-IFR Invention & Entrepreneurship Award in Robotics and Automation
  - Created in 2005 for outstanding achievements in commercializing innovative robotics and automation technology
- EURON/EUnited Robotics Technology Transfer Award
  - Created in 2003 in order to improve the quality of robotics research and to raise the profile of technology transfer between science and industry

Springer Tracts in Advanced Robotics

- B. Siciliano, O. Khatib, F. Groen (Editors)
  - H. Bruyninckx, R. Chatila, H. Christensen, P. Corke, P. Dario, R. Dillmann, K. Goldberg, J. Hollerbach, S. Lee, M. Kaneko, L. Kavraki, T. Salcudean, S. Thrun, Y. Xu, S. Yuta

star springer tracts in advanced robotics

- Record (5 years)
  - 50 published volumes
    - 23 monographs and 27 collections
  - 12 accepted volumes
    - 11 monographs and 1 collection

Springer Handbook of Robotics

- B. Siciliano, O. Khatib (Editors)
  - Hard cover, single volume
  - Electronic content (Internet, DVD)
  - Unveiled @ ICRA'08 May, Pasadena, CA
  - 6 years of work, 10000+ emails

A — Robotics Foundations (D. Orin) — 9

B — Robot Structures (F. Park) — 9

C — Sensing and Perception (H. Christensen) — 7

D — Manipulation and Interfaces (M. Kaneko) — 9

E — Mobile and Distributed Robotics (R. Chatila) — 8

F — Field and Service Robotics (A. Zelinsky) — 14

G — Human-Centered and Life-Like Robotics (D. Rus) — 8

- 7 Parts
- 64 Chapters
- 165 Authors
- 1600 Pages
- 950 Illustrations
- 5500 References

This is the end …
This is the beginning … (?)
Thanks!

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