The DEXMART project for advanced bimanual manipulation

Bruno Siciliano

Dipartimento di Informatica e Sistemistica
Università degli Studi di Napoli Federico II
siciliano@unina.it

Program

09:00–09:35

Michael Beetz (Technische Universität München), “Cognition-enabled everyday manipulation”

09:35–09:50

Bruno Siciliano (Università di Napoli Federico II), “DEXMART: Main achievements, discussion of open problems and research trends in the field”

09:50–10:15

Rainer Jäkel (FZI Universität Karlsruhe), “Programming by demonstration – a planning based approach”

10:15–10:40

Christoph Borst (DLR), “Observation and execution”

10:40–11:05

Daniel Sidobre (LAAS), “Human–robot interaction”

11:05–11:30

Luigi Villani (Università di Napoli Federico II), “Grasping and control of multifingered hands”

11:30–11:55

Gianluca Palli (Università di Bologna), “Innovative technologies for the next generation of robotic hands”

11:55–12:30

Oussama Khatib (Stanford University), “Robots and the human”

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Main achievements, discussion of open problems and research trends in the field

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The project

DEXterous and autonomous dual-arm/hand robotic manipulation with sMART sensory-motor skills: A bridge from natural to artificial cognition

Large-scale integrating project ICT–216239 supported by the European Commission under the 7th Framework Programme
Duration: 01.02.2008 – 31.01.2012
Cost: 8.1 M€ | Funding: 6.3 M€

Coordinator: Bruno Siciliano
Project Officer: Anne Bajart

www.dexmart.eu

The consortium

PRISMA Lab/DIS & DSF, Università di Napoli Federico II, Italy — **UNINA** Bruno Siciliano	LAAS, CNRS, France — **CNRS** Daniel Sidobre
Institut für Robotik und Mechatronik, DLR, Germany — **DLR** Gerhard Grunwald	Forschungszentrum Informatik an der Universität Karlsruhe, Germany — **FZI** Rainer Jäkel
OMG plc, United Kingdom — **OMG** Paul Smyth	DII, Seconda Università di Napoli, Italy — **SUN** Giuseppe De Maria
DEIS & DIEM, Alma Mater Studiorum Università di Bologna, Italy — **UNIBO** Claudio Melchiorri	LPA & EPO,Universität des Saarlandes, Germany — **USAAR** Chris May (LPA) Corinna Hahn (EPO)

The goal

DEXMART has the ambition to fill the gap between the use of robots in industrial environments and the use of future robots in everyday human and unstructured environments, contributing to reinforce European competitiveness in all those domains of personal and service robotics where dexterous and autonomous dual-hand manipulation capabilities are required

The contribution

DEXMART will primarily contribute to the **development of robotic systems endowed with dexterous and human-aware dual-arm/hand manipulation skills for objects, operating with a high degree of autonomy in unstructured real-world environments**

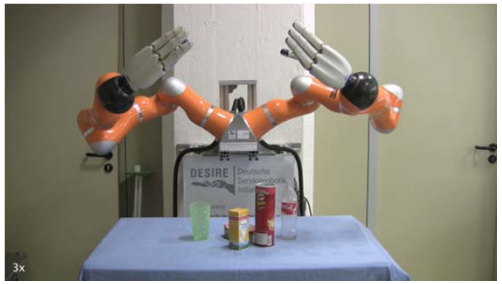
- Allow a dual-arm robot including two multi-fingered hands to **grasp and manipulate the same objects** (different shape, dimension and weight) **used by human beings**
- Manipulation will take place in **unsupervised, robust and dependable manner** so as to allow the robot to **safely cooperate with humans** for the execution of given tasks
- Robotic system able to **autonomously decide between different manipulation options**, and to **learn new action sequences** aimed at creating a **consistent and comprehensive manipulation knowledge base**
- Possible exploitation of high power-to-weight ratio of **smart materials and structures**, aimed at design of new hand components (finger, thumb, wrist) and sensors for **next generation of dexterous robotic hands**

The context

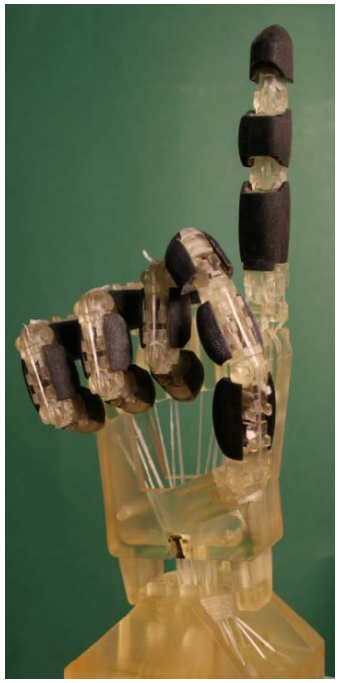
- Research domains
  - Programming by demonstration / Observation and execution
  - Human–robot interaction
  - New technologies and feedback control
- Benchmarking and experiments

DLR

UNINA



FZI

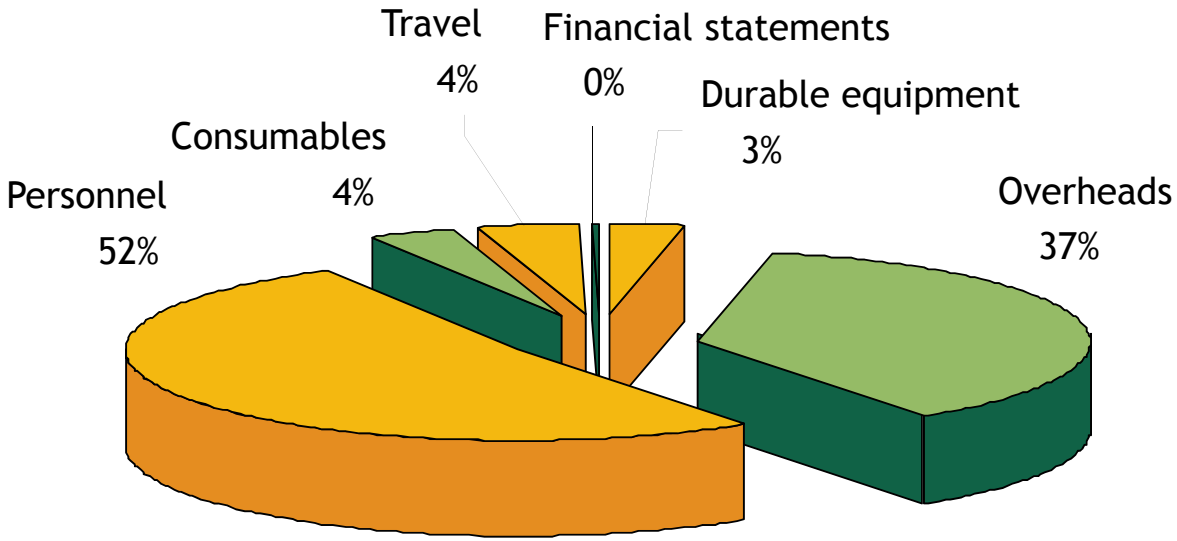


UNIBO

CNRS

The figures

- 866 person months (30 key scientists)
  - 798 pm on research and development
  - 23 pm on management
  - 45 pm on dissemination, exploitation, training
- 23 deliverables
- 38 internal reports
- 22 milestones
- Budget breakdown



The achievements

- Observation of dual-arm/hand manipulation activities performed by humans, where the observation is done at different levels of granularity to deduce goals and strategies at different levels of abstraction
- Representation of objects, obstacles, grasps and human capabilities and behaviours, leading to models of scene dynamics at different levels of abstraction from basic actions to high level manipulation activities
- Generalized manipulation strategy representation from observation of trajectory level human demonstrations including temporal aspects
- Complete dynamic model and control structure of fingers and hand, including nonlinear dynamic model of tendon and joint friction
- Development of new (patent pending) twisted string actuator, design of innovative hand based on compliant joints and fast prototyping, equipped with new (patent pending) tactile sensor
- Specification of common matrix structure aimed at describing different benchmarks

The record

- Publications
  - 6 journal papers + 1 book chapter + 95 conference papers (1 finalist @ ICRA'10)
- Project presentations
  - 45 scientific events and seminars
- Press club
  - 15 audio/visuals + 70 paper/internet clippings
- Training
  - 3 topical workshops open to all scientists
- Cooperation with other projects
  - 3 joint meetings + 2 workshops + 1 summer school with GRASP+HANDLE
- Exploitation
  - Patent application on twisted string actuator by USAAR
  - Patent application on tactile sensor by SUN
  - Replacement of one reviewer after cooperation with UNIBO, USAAR and SUN

The impact

- Potential relevance for leading-edge European robot manufacturers
  - KUKA Roboter GmbH as external observer and advisor KUKA
- Bimanual manipulation for automotive industry
  - Typical assembly procedures constituted by tasks requiring dual-arm manipulation of objects and tools similar to those generally used by production workers

Daimler pilot plant

- Dexterous hands appealing to SMEs
  - Manipulation of work pieces of different sizes, shapes and weights currently requiring different grasping tools and frequent changes
- Human–robot cooperation for aeronautic industry
  - Assist humans in simple repetitive tasks, e.g. riveting and assembly
- In the long run ... human-centered tasks
  - Robot companions for service applications (homes, public environments, etc.)

The open problems

- Build and maintain a model of the environment, particularly humans
- Reactive planning in human environments
- Control to emulate human behavior
- Tactile exploration of objects for grasping and manipulation
- Grasp planning for dual-hand grasps
- Dynamic manipulation using both vision and force (juggling, ...)
- Fine manipulation of lightweight and flexible objects
- Complete hand sensorisation (not only fingertips) for whole hand manipulation
- Reliable and cost-effective robot hands with tactile and force/torque sensors, to be used in real applications in industrial and social environments
- Miniaturized and powerful actuators, miniaturized sensors
- Materials for soft pads
- …

Thanks for your kind attendance ☺

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