

## DIS - Research areas

Algorithm Design and Engineering  
Artificial Intelligence and Knowledge Representation  
Combinatorial Optimization  
Computer Graphics, Computer Vision and Perception  
Computer Networks and Pervasive Systems  
Continuous Optimization  
Data Management and Service-Oriented Computing  
Distributed Systems  
High Performance and Dependable Computing Systems  
Human-Computer Interaction  
Industrial Organization and Management  
Modeling, Identification, and Control in Biological and Biomedical Systems  
Multi-Agent and Multi-Robot Systems  
Networked Systems  
Nonlinear Systems and Control  
R&D, Innovation, and Internationalization  
Robotics  
Web Algorithmics and Data Mining

Research report 2011



DIPARTIMENTO DI INGEGNERIA INFORMATICA  
AUTOMATICA E GESTIONALE ANTONIO RUBERTI



SAPIENZA  
UNIVERSITÀ DI ROMA

**Research report 2011**

Dipartimento di Ingegneria informatica  
automatica e gestionale Antonio Ruberti  
<http://www.dis.uniroma1.it>

Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti

**Dipartimento di Ingegneria informatica automatica e gestionale**  
**Antonio Ruberti**  
**Sapienza Università di Roma**

**Research report 2011**

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# 1 Introduction

The present report provides an overview of the research carried out at the Department of Computer, Control, and Management Engineering Antonio Ruberti (DIAG) of the Sapienza University of Rome, during the year 2011.

DIAG (formerly known as DIS - *Dipartimento di Informatica e Sistemistica Antonio Ruberti*) was established in 1983 as an evolution of the *Istituto di Automatica*; in 2001 it was named after Antonio Ruberti, the eminent scholar who founded it. For many years DIAG was distributed over three sites far apart from each other. In May 2007 it moved to the completely renewed premises of Via Ariosto 25, in the center of Rome. In 2011 the department changed its Italian name to the new *Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti* with the aim of better representing its current expertise and interests.

DIAG is a center for research and education at the undergraduate and graduate levels in computer, system, and management sciences.

Basic research is the main goal of DIAG, with a strong emphasis on interdisciplinary research, on applications that stimulate basic research, and with a specific attention to technology transfer and dissemination of results.

Collaborations are maintained with researchers in other university departments, research institutions and companies, in Italy and abroad.

The main educational goal is to prepare students for professional, research and teaching careers either in universities or in industries in information technologies, automation, and management.

The faculty of DIAG in 2011 consists of 29 full professors, 22 associate professors, and 26 assistant professors (*ricercatori*). They provide education at the undergraduate and graduate levels to several programs of the two schools of engineering at Sapienza (*Facoltà di Ingegneria dell'informazione, Informatica e Statistica* and *Facoltà di Ingegneria Civile ed Industriale*), with main responsibility in the curricula in informatics, systems and control, and engineering management. Teaching activities are not illustrated in this report; a description may be found at <http://www.dis.uniroma1.it> under the entry "Teaching".

Furthermore, DIAG offers two PhD programs, and cooperates with three PhD programs offered by other departments. They are briefly described in Section 2.4 of this report.

Research activities at DIAG are organized in 19 research areas. This organization is reflected in the structure of Section 3, where the research areas are described with a short description of their main research lines, together with the list of people involved, and the collection of publications appeared in 2011.

## 2 General Information

### 2.1 Location

The location of DIAG is the building known as “Scuola Silvio Pellico”, in Via Ariosto 25, Rome.

DIAG is on the web at <http://www.dis.uniroma1.it>.

### 2.2 Facilities

#### Library

The DIS library was first established in 1970 at the Istituto di Automatica. In 2007, the library moved with the department to its current location on Via Ariosto, and there are two reading rooms available for students. Its holdings contain approximately 11,000 books and conference proceedings, 392 journal subscriptions (94 of which are currently active); the Library complements its collection with user access to all the key online resources, bibliographic databases, and scientific content discovery services. The library facilities are also available to students and faculty of other departments and universities.

In 2011, the department library began to acquire books in electronic format. The library now has over 500 ebook titles available, accessible both on the library website and in the central online catalog. Eleven eReaders have been purchased for student use, and the library is currently testing the use of the eReaders as a course-related-content delivery system for articles, references and resources relevant to courses taught at the Department.

During the year 2011, the DIAG library continued the organization of the series of invited lectures *Incontri al Chiostro*, under the supervision of professors Marilena VENDITTELLI and Alberto MARCHETTI SPACCAMELA. The lectures of 2011 were:

Jean-Paul LAUMOND Robotics: Hephaistos reoffends. April 29, 2011

#### Laboratories

DIAG hosts several research and educational laboratories. The following list reports name, location, purpose, and the person in charge for each of them.

##### *ALCOR - Cognitive Robotics Laboratory*

Via Ariosto 25 - basement

The main thrust in this laboratory is the development and experimental validation of advanced planning and control techniques for industrial and service robots.

Web: <http://www.dis.uniroma1.it/~alcor>

Head: Fiora PIRRI

##### *Algorithms Engineering Laboratory*

Via Ariosto 25 - wing B1

The laboratory is devoted to the engineering and the experimental performance analysis of combinatorial algorithms and their applications.

Web: <http://www.dis.uniroma1.it/~ae>

Head: Camil DEMETRESCU

*Automation Laboratory*

Via Ariosto 25 - basement

The laboratory is devoted to the training of students on the design and realization of simple control systems.

Head: Claudio GORI GIORGI

*BiBiLab - Bioengineering and Bioinformatics Laboratory*

Via Ariosto 25 - basement

The laboratory is devoted to the study of the neuroengineering field and the development of applications based on Brain Computer Interfaces (BCI). Measurements on healthy human subjects and patients are performed in collaboration with the Department of Human Physiology and Pharmacology and with the IRCCS "S. Lucia".

Head: Serenella SALINARI

*DAMSO Laboratory*

Via Ariosto 25 - basement

The laboratory aims at developing models and testing efficient algorithms for processing real world data from industrial and biosystems engineering.

Head: Alberto DE SANTIS

*Data And Service Integration Laboratory (DASILab)*

Via Ariosto 25 - room 213, wing B2

The laboratory is devoted to the development of software research prototypes for service-based and data-integration systems.

Web: <http://www.dis.uniroma1.it/dasilab>

Head: Maurizio LENZERINI

Organization: Massimo MECELLA

*Joint Lab on Security Research*

Via Ariosto 25 - wing B1

The Joint-Lab on security research with Sapienza Innovazione has the mission to create a critical mass of researchers of La Sapienza around system and software security in complex environments. Results of research of the joint-lab are heavily oriented toward innovation and the creation of new technology companies.

Web: <http://www.dis.uniroma1.it/~labsec>

Head: Roberto BALDONI

*Management Engineering Laboratory*

Via Ariosto 25 - room A122 and A123, wing A1

The laboratory is devoted to the development of mathematical models and solution algorithms for Management Engineering problems.

Web: <http://www.dis.uniroma1.it/~labinggest>  
Head: Massimo ROMA

*Middleware Laboratory - MIDLAB*

Via Ariosto 25 - wing B1

The primary goal of MIDLAB is to support leading-edge research and development on middleware, bridging the gap between the latest research results and the current technologies.

Web: <http://www.dis.uniroma1.it/~midlab>  
Head: Roberto BALDONI

*Network Control Laboratory*

Via Ariosto 25 - room 215, wing A2

The laboratory is devoted to the design, simulation, and experimental validation of advanced resource management, service management and interoperability management procedures for wireless and wired telecommunication networks as well as in energy distribution networks.

Web: <http://labreti.ing.uniroma1.it/>  
Head: Francesco DELLI PRISCOLI

*Robotics Laboratory*

Via Ariosto 25 - basement

The laboratory is devoted to the development and experimental validation of advanced planning and control techniques for industrial and service robots.

Web: <http://www.dis.uniroma1.it/~labrob>  
Head: Giuseppe ORIOLO

*ROCOCO - Robot COgnitivi COoperanti*

Via Ariosto 25 - basement

The laboratory of SPQR (Soccer Player Quadruped Robots) teams participating in RoboCup, AIBO, NAO and Rescue Robots.

Web: <http://labrococo.dis.uniroma1.it/>  
Head: Daniele NARDI

*Systems and Control Laboratory*

Via Ariosto 25 - basement

The laboratory is devoted to the development and experimental verification of new control strategies.

Web: [http://labsis.dis.uniroma1.it/LSW\\_R2/](http://labsis.dis.uniroma1.it/LSW_R2/)  
Head: Salvatore MONACO

*Wireless Sensor Networks Laboratory*

Via Ariosto 25 - basement

The laboratory is devoted to the development and experimental verification of protocols



and algorithms for WSNs.

Web: <http://wiserver.dis.uniroma1.it/cms/>

Head: Andrea VITALETTI

Additional information on the DIAG laboratories may be found at <http://www.dis.uniroma1.it/>.

### **Educational Laboratories**

DIAG manages two educational laboratories of the School of Engineering, used for hands-on teaching and for self-studying. The laboratories are named after Paolo Ercoli, the founder of the Computer science component of the department. Moreover two more laboratories are available for students within DIAG's building. Educational laboratories are on the web at the address <http://www.dis.uniroma1.it/>.

*Computer Science Laboratory Paolo Ercoli for introductory courses*

Via Tiburtina 205, Roma.

About 150 stations are available for undergraduate teaching.

Person in charge: Umberto NANNI.

*PC and Workstations Laboratory Paolo Ercoli for advanced courses*

Via Eudossiana 18, Roma.

About 75 PC and workstations are available for the graduate teaching.

Person in charge: Umberto NANNI.

*Management Engineering Laboratory*

Via Ariosto 25 - room A122 and A123, wing A1

11 PCs are available. The laboratory is devoted to thesis students for the development of mathematical models and solution algorithms for Management Engineering problems.

Web: <http://www.dis.uniroma1.it/~labinggest>

Person in charge: Massimo ROMA

*Software Development (Thesis Students) Laboratory*

via Ariosto 25 - rooms A1 and A2

The laboratory is devoted to the training of students on the design and implementation of software systems.

Person in charge: Massimo MECELLA

## 2.3 People

*Director* - Claudio LEPORELLI

*Administration Head* - Giovanna BIANCO

### Faculty

#### *Professors*

Giorgio AUSIELLO (up to October 2011)

Roberto BALDONI

Stefano BATTILOTTI

Carlo BRUNI (up to October 2011)

Luigia CARLUCCI AIELLO

Giuseppe CATALANO (from December 2011)

Tiziana CATARCI

Bruno CICIANI

Giuseppe DE GIACOMO

Alessandro DE LUCA

Francesco DELLI PRISCOLI

Gianni DI PILLO

Francisco FACCHINEI

Claudio GORI GIORGI

Luigi GRIPPO

Alberto ISIDORI

Maurizio LENZERINI

Stefano LEONARDI

Claudio LEPORELLI

Stefano LUCIDI

Alberto MARCHETTI SPACCAMELA

Salvatore MONACO

Umberto NANNI

Daniele NARDI

Alberto NASTASI

Fiora PIRRI

Francesca SANNA RANDACCIO

Antonio SASSANO

Marco SCHAEFER

#### *Associate professors*

Luca BENVENUTI

Fabrizio D'AMORE

Cinzia DARAIO (from December 2011)

Camil DEMETRESCU

Alberto DE SANTIS

Lorenzo FARINA

Luca IOCCHI (from October 2011)

Domenico LAISE

Leonardo LANARI

Paolo LIBERATORE

Carlo MANNINO

Marco Antonio MARINI (from December 2011)

Giuseppe ORIOLO

Laura PALAGI

Francesco QUAGLIA

Pierfrancesco REVERBERI

Massimo ROMA

Riccardo ROSATI

Serenella SALINARI

Silvio SALZA

Giuseppe SANTUCCI

Marco TEMPERINI

#### *Assistant professors (ricercatori)*

Alessandro AVENALI

Luca BECCHETTI

Roberto BERALDI

Silvia BONOMI (from December 2011)

Renato BRUNI (from December 2011)

Claudia CALIFANO

Febo CINCOTTI (from December 2011)

Rosa Maria DANGELICO (from December 2011)

Claudio DE PERSIS

Paolo DI GIAMBERARDINO

Alessandro DI GIORGIO (from October 2011)

Marco FRATARCANGELI (from December 2011)

Giorgio GRISETTI

Daniela IACOVIELLO

Luca IOCCHI (up to September 2011)

Domenico LEMBO

Giorgio MATTEUCCI

Massimo MECELLA

Carlo Maria MEDAGLIA

Fabio NONINO

Fabio PATRIZI (from October 2011)

Antonio PIETRABISSA

Antonella POGGI (from May 2011)

Leonardo QUERZONI

Roberta SESTINI

Marilena VENDITTELLI

Andrea VITALETTI

## Staff

### *Research associates and post docs*

Carola AIELLO  
 Fabio ALOISE  
 Laura ASTOLFI  
 Aris ANAGNOSTOPOULOS  
 Lorenzo BERGAMINI  
 Taigo Maria BONANNI  
 Silvia CANALE  
 Andrea CARBONE  
 Marco CASTRUCCI  
 Massimo CEFALO  
 Anna D'ANNUNZIO  
 Fabrizio GRANDONI  
 Luigi LAURA  
 Giorgia LODI  
 Donato MACONE  
 Andrea MERCURIO  
 Andrea ONOFRI  
 Papadakis PANAGIOTIS  
 Alessandro PREVITI  
 Andrea RIBICHINI  
 Marco RUZZI  
 Piotr SANKOWSKY  
 Arnab SINHA  
 Vincenzo SURACI  
 Lorenzo TAGLIAFERRI  
 Massimo VISCONTI

### *Administration staff*

Amelia ARRICALE  
 Giovanna BIANCO  
 Flavia CAGNIZI  
 Antonietta CANGELLI  
 Ugo CINELLI  
 Beatrice DE CARLO (up to June 2011)  
 Giuditta FILOMENA  
 Sabrina GIAMPAOLETTI  
 Tiziana VALENTINI  
 Maria Pia VANDILLI

### *Technical staff*

Anna Paola DI RISIO  
 Andrea DORI  
 Giuseppe FILACI  
 Marco GIULIANI  
 Marcello PANI  
 Tiziana TONI

### *Auxiliary services*

Antonio SIMEONI

### *Library*

Laura ARMIERO  
 Roberta PROIETTI SEMPRONI

## 2.4 Doctoral Programs

DIAG directly hosts the PhD programs in *Computing Science and Engineering* and in *Systems Engineering*. Moreover, DIAG cooperates in the PhD programs in *Bioengineering*, hosted by the Department of Electric, Computer and System Sciences of the University of Bologna, in *Operations Research*, hosted by the Department of Statistical Sciences of the University of Rome "La Sapienza", and in *Economics and Management of Technology* hosted by the Department of Management Engineering of the University of Bergamo.

### **Bioengineering**

DIAG participates in the PhD program in Bioengineering coordinated by the Department DEIS of the University of Bologna.

The research topics are: modeling of biomedical systems, processing of biomedical data, signals and images, biomedical instrumentation, medical informatics, biomechanics, prostheses, and bio-materials.

*PhD students (working at DIAG)*

<u>XXV course</u>	<u>XXVI course</u>
Ilenia TOPPI	Pietro ARICÒ Francesca SCHETTINI

**Computing Science and Engineering**

The council of professors of the PhD program in Computing Science and Engineering is coordinated by Giuseppe DE GIACOMO.

The research topics are: theory of algorithms, computer systems, databases, programming languages, theoretical computer science, image processing, artificial intelligence, cognitive robotics, VLSI, computational logics, performance evaluation, distributed software architectures, computer networks and security.

*PhD students*

<u>XXIII course</u>	<u>XXIV course</u>	<u>XXV course</u>	<u>XXVI course</u>
Matia PIZZOLI	Lorenzo BERGAMINI Pierangelo DI SANZO Luca FILIPPONI Letizia MARCHEGIANI Roberto PALMIERI Marco PLATANIA Domenico Fabio SAVO	Adriano CEROCCHI Riccardo DE MASELLIS Claudio DI CICCIO Ricardo DODDS Paolo FELLI Donatella FIRMANI Mario GIANNI Andrea MARRELLA Ida MELE Luca MONTANARI Hani QUSA Roberto VITALI	Leonardo ANIELLO Floriana DI PINTO Francesco LEOTTA Khalil M.H. AL MASSRI Alessandro PELLEGRINI Sebastiano PELUSO Diego RUGHETTI Alessandro RUSSO Suzanne VAN DE STER

New admissions for the XXVII course are:

Giuseppe Antonio DI LUNA  
Bruno CAFARO  
Mario CARUSO  
Cristina CIVILI  
Riccardo COLINI BALDESCHI  
Thien NGUYEN DUC  
Francesco FICAROLA  
Andrea PENNISI  
Valerio SANTARELLI  
Erfan SHOJAEI BARJUEI

### Economics and Management of Technology

DIAG participates in the PhD program in Economics and Management of Technology coordinated by the Department of Management Engineering of the University of Bergamo. The research topics are: Industrial Organization, Economics of Innovation, Management and Finance.

*PhD students (working at DIAG)*

XXV course

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Tiziana D'ALFONSO

### Operations Research

The council of professors of the PhD program in Operations research is hosted by the Department of Statistical Sciences of the University of Rome "La Sapienza" and is coordinated by Stefano LUCIDI.

The research topics are: Combinatorial optimization, nonlinear programming, network design, neural networks, logistics, management systems, and industrial systems economy.

*PhD students (working at DIAG)*

XXIII course

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Serena TEBALDO

XXIV course

---

Marianna DE SANTIS  
Andrea IANNI  
Carla MICHINI  
Mauro PIACENTINI

XXV course

---

Gianpiero BIANCHI  
Vittorio LATORRE

XXVI course

---

Alessandra REALE

New admissions for the XXVII course are:

Andrea MANNO  
Olimpia OTTAVIANI

### Systems Engineering

The council of professors of the PhD program in Systems Engineering is coordinated by Carlo BRUNI.

The research topics are: Systems theory, automatic control, nonlinear systems, intelligent control, robotics, flexible manufacturing systems, biosystems, modelling, identification, optimal control, and resource management for wireless systems.

*PhD students*

XXIV course	XXV course	XXVI course
Laura FOGLIATI	Andrea ABELLI	Giorgia CHINI
Fabrizio FLACCO	Antonio D'ANGELO	Andi PALO
Lorenzo LAMPARIELLO	Andrea FIASCHETTI	Martina PANFILI
Mattia PETRUCCIANI	Guido ODDI	Silvia PARIS
Simone SAGRATELLA	Marco PAOLETTI	Margherita PETROCCHI
Paolo STEGAGNO	Pietro PELITI	Lorenzo ROSA
	Daniele PUCCI	

New admissions for the XXVII course are:

Francesco LIBERATI  
 Giovanni MATTEI  
 Antonio PAOLILLO  
 Raffaele RUINI  
 Letterio ZUCCARO

**PhD theses completed in 2011***Bioengineering*

Federico PAPA  
*Optimal solution for a cancer radiotherapy problem*  
 Advisor: Carlo BRUNI  
 April 2011

*Computing Science and Engineering*

Beniamino ACCATTOLI  
*Jumping around the box: Graphical and operational studies on Lambda-Calculus and Linear Logic*  
 Advisor: Stefano GUERRINI

Andrea CARBONE  
*Learning from the visual input statistics*  
 Advisor: Fiora PIRRI

Ugo COLESANTI  
*Information Gathering in Resource Constrained Wireless Networks*  
 Advisor: Andrea VITALETTI

Shah Rukh HUMAYOUN  
*Incorporating Usability Evaluation in Software Development Environments*

Advisor: Tiziana CATARCI

Matteo LEONETTI  
*Reinforcement learning in plan space*  
Advisor: Luca IOCCHI

Gabriele RANDELLI  
*Improving Human-Robot Awareness through Semantic-driven Tangible Interaction*  
Advisor: Daniele NARDI

Domenico Davide LAMANNA  
*Performance monitoring and Progressive privacy in Virtual Distro Dispatcher, a Desktop-as-a-Service solution*  
Advisor: Roberto BALDONI

*Economics and Management of Technology*

Anna D'ANNUNZIO  
*Multi-Product Firms and Quality Differentiation: Product Bundling and Content Provision in Two-Sided Media Markets.*  
Advisor: Pierfrancesco REVERBERI  
April 2011

*Systems Engineering*

Enrico GENTLI  
*Sistemi digitali campionati non lineari.*  
Advisor: Salvatore MONACO  
April 2011

Laura PIMPINELLA  
*An Optimal Control Approach to the Resource Management Problem: from Telecommunication Networks to Smart Grids.*  
Advisor: Francesco DELLI PRISCOLI  
April 2011

Filippo RODRIGUEZ  
*Development of Code and Phase Tracking Algorithms for GNSS signals in low C/N and high dynamics scenarios.*  
Advisor: Francesco DELLI PRISCOLI  
April 2011

Valentina RUSSO

*Analisi Statistica di Pseudoimmagini OCT della Retina per Scopi Diagnostici.*

Advisor: Carlo BRUNI

April 2011

Marco VEROLI

*System wide Safety in Intelligent Intersections.*

Advisor: Francesco DELLI PRISCOLI

April 2011

## 2.5 Visiting Scientists and Scholars

DIAG hosts visiting scientists and scholars from all over the world. Here we list the visitors that spent at least one month at DIAG during 2011.

Jean-Paul LAUMOND, CNRS-LAAS Toulouse, France (March-October)

Alexander KLEINER, University of Freiburg, Germany (March-May)

Keith SULLIVAN (PhD student), George Mason University, USA (July-August)

Erdi AKER (Erasmus Master Student), Sabanci University, Istanbul, Turkey (July-September)

## 2.6 Contracts

DIAG carries on its research on contracts with public funding agencies and companies. Some of them continue over more than one year. Contractor, funding to DIAG in Euro, title, project leader and duration of each contract are detailed in the list below. The titles of the contracts with Italian entities are reported in Italian.

### Contracts with the European Union (E.U.)

- FP7-CP, € 435.000, ACSI - Artifact-centric service interoperation, G. De Giacomo (up to 31/05/13)
- EUREKA Eurostars, €110.500, BLEND - Blending technologies for ubiquitous real-time data access, R. Baldoni (up to 02/05/12)
- FP7-SME, € 330.000, Collective - emerging communities for collective innovation: ict operational tool and supporting methodologies for sme associations, C. Leporelli (up to 31/12/12)
- LLP KA3, €59.863, E-Learning Fitness, U. Nanni (up to 31/12/13)
- FP7-IRSES, € 18.000, EUSACOU - European south american network on combinatorial optimization under uncertainty, A. Marchetti Spaccamela (up to 31/07/14)



- FP7-IP, €285.680, FI-WARE - Future Internet Core Platform, F. Delli Priscoli (up to 30/04/14)
- FP7-CP, €200.000, FRONTS - Foundations of adaptive networked societies of tiny artifacts, A. Marchetti Spaccamela (up to 30/04/11)
- FP7-CP, €62.680, GreenerBuilding - An ubiquitous embedded systems framework for energy-aware buildings using activity and context knowledge, M. Mecella (up to 31/08/13)
- FP7-People/2009-IIPP, €83.500, MANON - Methods for advanced multi-objective optimization of complex nanoscale circuits, G. Di Pillo (up to September 2013)
- ENIAC, €85.000, MODERN - Modeling and design of reliable nanoelectronics devices, G. Di Pillo (up to February 2012)
- FP7-CP, €729.424, NIFTi - Natural human-robot cooperation in dynamic environments, F. Pirri (up to 31/12/13)
- ARTEMIS, €240.000, nSHIELD - new embedded systems architecture for multi-layer dependable solutions, F. Delli Priscoli (up to 31/08/14)
- FP7-CP, €256.512, P2P-NEXT - Next generation peer-to-peer content delivery platform, F. Delli Priscoli (up to 30/4/12)
- ERC-STG, €332.200, PAAI — Practical approximation algorithms, S. Leonardi (up to 30/11/14)
- FP7-CSA, €54.420, PANORAMA - Pervasive adaptation network for the organization of the research agenda and the management of activities, A. Marchetti Spaccamela (up to 31/05/11)
- EUREKA Eurostars, €75.000, pharmaAID, A. Vitaletti (up to 31/12/11)
- FP7-NOE, €297.600, PROMISE - Participative research laboratory for multimedia and multilingual information systems evaluation, G. Santucci (up to 31/08/13)
- ARTEMIS, €122.430, pSHIELD - Pilot embedded systems architecture for multi-layer dependable solutions, F. Delli Priscoli (up to 31/12/11)
- FP7-CP, €815.392, SAPHARI - Safe and Autonomous Physical Human-Aware Robot Interaction, A. De Luca (up to 31/10/15)
- FP7-CP, €570.000, SM4All - Smart homes for all: an embedded middleware platform for pervasive and immersive environments for all, R. Baldoni (up to 31/08/11)
- FP7-CP, €348.880, Smart-Vortex - scalable semantic product data stream management for collaboration and decision making in engineering, T. Catarci (up to 30/09/14)

- FP7-CP, €173.608, SMARTV2G - Smart Vehicle to Grid Interface, C. Mannino (up to 31/05/14)
- FP7-Marie Curie IIF, €158.758, SNAPS - Social networks: algorithms, privacy and security, S. Leonardi (up to 31/05/12)
- ARTEMIS, €206.433, SOFIA - Smart objects for intelligent applications, R. Baldoni (up to 31/12/11)
- LLP Leonardo da Vinci, €45.114, Understand IT, M. Temperini (up to 26/12/12)
- FP7-CP, Speaky for Robots, D. Nardi (up to 30/04/12)

### Contracts with Italian Institutions

- Regione Lazio, €728.400, Convenzione per gli interventi di riqualificazione dei laboratori di ricerca, il loro ammodernamento e l'acquisizione di impianti e macchinari, Progetto Codice ULS 002 Sensoristica interconnessa per la sicurezza, R. Baldoni (up to July 2011)
- Herzum Software Srl, €56.250, Piano innovazione aziendale (PIA) relativo al progetto di ricerca e sviluppo tecnologico "COSMFactory", M. Mecella (up to 19/01/12)
- Fondazione S. Lucia, €81.000, Progetto ARISLA Brain-computer interface devices to support individual autonomy in locked-in individuals, M. Mecella (up to 31/10/13)
- MISE, Industria 2015, €83.830, Progetto di innovazione industriale mobilità sostenibile, programma "Context Aware Mobility Platform " (CAMP), L. Iocchi (up to 31/12/11)
- ASI – Agenzia Spaziale Italiana, €294.735, SARFIRE – Spaceborn SAR imagery and environmental data fusion for the dynamical evaluation of land regions susceptibility to fire, F. Pirri (up to 09/02/12)
- ROMA CAPITALE-Dipartimento Risorse Tecnologiche e-Servizi delegati, €20.000, Studio/ricerca sul tema "Analisi delle infrastrutture e delle applicazioni esistenti da mettere in gara; definizione delle linee guida per la stesura della documentazione necessaria", C. Demetrescu (up to 31/12/12)
- ROMA CAPITALE-Dipartimento Attività Economico-Produttive, U.O. Osservatorio sul Lavoro, €24.742, Studio/ricerca sul tema "Analisi delle infrastrutture e delle applicazioni esistenti da mettere in gara; definizione delle linee guida per la stesura della documentazione necessaria", L. Carlucci (up to 05/03/12)
- POSTE ITALIANE S.p.A., €160.000, Studio/ricerca sul tema "Identificazione cause e responsabilità disservizio Poste", B. Ciciani (up to 12/08/11)

- ROMA CAPITALE-Dipartimento Risorse Tecnologiche e-Servizi delegati, €20.000, Studio/ricerca sul tema “Nuovo sistema informativo dei tributi e delle attività produttive” , R. Baldoni (up to 30/09/11)
- ISTAT – Istituto Nazionale di Statistica, €40.000, Studio/ricerca sul tema “Realizzazione di nuove metodologie basate sull’utilizzo di tecnologie di Ricerca Operativa per il controllo a livello micro-amacro dei dati, implementazione delle stesse”, G. Di Pillo (up to 11/10/12)
- ENEA – Agenzia nazionale per le nuove tecnologie, l’energia e lo sviluppo economico sostenibile, €19.000, Studio/ricerca sul tema “Studio per l’implementazione del sistema di controllo della densità del plasma del Tokamak FTU per il C.R. ENEA di Frascati”, S. Monaco (up to 08/05/11)
- ISPRA – Istituto per la protezione e la ricerca ambientale, Dipartimento tutela acque interne e marine, €25.000, Studio/ricerca sul tema “Tecnologie di accesso alle informazioni sulla tutela delle acque”, M. Schaerf (up to 28/03/11)
- MISE, Industria 2015, Speaky Acutattile, L. Carlucci Aiello and D. Nardi (up to 30/06/14)

### Contracts with Companies

- Sistemi Software Integrati SpA, €99.600, Studio/ricerca sul tema Addestramento degli automi del sistema BEE SAFE - , D. Nardi (up to 21/03/13)
- RADIOLABS Consorzio Università Industria, €77.500, Studio/ricerca sul tema SAFEDEM Project - Space Assets for Demining Assistance (Ladmine detection Service), F. Delli Priscoli (up to 31/03/12)
- THALES Alenia Space Italia SpA, €20.000, Studio/ricerca sul tema “Architettura, algoritmi e protocolli di gestione delle risorse per un Sistema di instradamento e connettività dinamica satellitare”, F. Delli Priscoli (up to 02/01/12)
- Mercantini Mobili srl, €14.360, Studio/ricerca sul tema Progetto DesigNET - INDUSTRIA 2015 “Made in Italy” di cui al bando MISE 10/07/08, T. Catarci (up to 31/12/12)
- iGUZZINI Illuminazione SpA, €13.600, Studio/ricerca sul tema Progetto DesigNET - INDUSTRIA 2015 “Made in Italy” di cui al bando MISE 10/07/08, T. Catarci (up to 31/12/12)
- Teuco Guzzini SpA, €10.600, Studio/ricerca sul tema Progetto DesigNET - INDUSTRIA 2015 “Made in Italy” di cui al bando MISE 10/07/08, T. Catarci (up to 31/12/12)

- Indesit Company SpA, €10.600, Studio/ricerca sul tema Progetto DesigNET - INDUSTRIA 2015 "Made in Italy" di cui al bando MISE 10/07/08, T. Catarci (up to 31/12/12)
- INDEL B SpA, €5.050, Studio/ricerca sul tema Progetto DesigNET - INDUSTRIA 2015 "Made in Italy" di cui al bando MISE 10/07/08, T. Catarci (up to 31/12/11)
- FIAM Italia SpA, €14.360, Studio/ricerca sul tema Progetto DesigNET - INDUSTRIA 2015 "Made in Italy" di cui al bando MISE 10/07/08, T. Catarci (up to 31/12/12)
- GIBAM Shops SpA, €14.360, Studio/ricerca sul tema Progetto DesigNET - INDUSTRIA 2015 "Made in Italy" di cui al bando MISE 10/07/08, T. Catarci (up to 31/12/12)
- GEPIN S.p.A., €20.723, Studio/ricerca sul tema Revisione e innovazione nell'area della tecnologia dell'informazione, F. D'Amore (up to 17/03/12)
- University Of Nevada, €89.000, Studio/ricerca sul tema Smart monitoring of complex public scenes (Subagreement n. UNR-11-98) , L. Iocchi (up to 15/04/13)
- THALES Alenia Space Italia SpA, €55.425, Studio/ricerca sul tema Studi Innovativi di Missione e Rete di Nuova Generazione, F. Delli Priscoli (up to 31/12/12)
- DB Consulting srl - , €120.000, Studio/ricerca sul tema Sviluppo di una ontologia e mapping tra ontologia e sorgenti di dati, M. Lenzerini (up to 30/04/11)
- SELEX Communications SpA, €28.000, Studio/ricerca sul tema WICOSMO Project (Wireless Cognitive Sensors Network per Monitoraggio ambientale), F. Delli Priscoli (up to 30/09/11)
- Act Solutions Srl, €30.000, Studio/ricerca sul tema "Ottimizzazione – simulazione e previsione con particolare riferimento allo sviluppo e sperimentazione di metodi da utilizzare in applicazioni nell'ambito delle attività di ACT", G. Di Pillo (up to 28/01/11)
- SPIN Applicazioni Magnetiche srl, €16.500, Studio/ricerca sul tema "Programmi di Ottimizzazione per la Progettazione in Ambito Elettromeccanico", G. Di Pillo (up to 12/12/11)
- Space Software Italia Spa, €126.700, Studio/ricerca sul tema "SAMAS – Sottosistema di Cooperazione", D. Nardi (up to 27/02/11)
- Sistemi Software Integrati SpA, €22.800, Studio/ricerca sul tema "SAMAS – Sottosistema di Cooperazione" Allestimento dimostrazione del sistema multi robot, D. Nardi (up to 22/07/11)
- DUEL SpA, €110.000, Studio/ricerca sul tema "Sistema avanzato per pubblicità virtuale tridimensionale", D. Nardi, L. Carlucci Aiello and L. Iocchi (up to 12/06/12)

- IBM Italia Spa, € 300.000, Studio/ricerca sul tema “Sviluppo di una ontologia in ambito bancario, e Mapping tra ontologie e sorgenti di dati”, M. Lenzerini (up to 31/07/12)

### Research Agreements (Convenzioni)

- Consorzio Interuniversitario Nazionale per l’Informatica (CINI) (up to 24/04/2014)
- Fondazione Ugo Bordoni (FUB) (up to 07/03/2011)
- Nous Informatica srl (up to 10/07/2011)
- Istituto Tecnico Vallauri, Società Open Informatica srl, Società Master Brain di Stefano Fava (up to 03/02/2011)
- Fondazione S. Lucia (up to 14/11/2013)
- Agenzia delle Entrate (up to 11/10/2011)
- CRAT Consorzio per la ricerca nell’automatica e nelle telecomunicazioni (up to 31/03/2012)
- CISIT S.c.r.l. (up to 12/12/2013)
- IRCCS San Raffaele Pisana, Roma (up to 22/09/12)

## 2.7 Seminars and Workshops

Many scientists are invited to deliver seminars at DIAG each year. Below is a list of seminars for the year 2011, in chronological order. Also the Workshops organized at DIAG are reported, with the exception of the project meetings.

- January 17-21, *Learning and Intelligent OptimizatioN* (LION 5).
- January 20, Donald R. Perlis, The University of Maryland, *Chippy’s Recovery*.
- January 24, Leonid Libkin, School of Informatics, University of Edinburgh, *Incomplete Information and Certain Answers in General Data Models*.
- March 1, Sara Mattia, Technische Universität Dortmund, *Separating Tight Metric Inequalities by Bilevel Programming*.
- March 3, Andrea Bonaccorsi (Università di Pisa), Cinzia Daraio (Università di Bologna) and Henk Moed (University of Leiden), *Dalla valutazione alla pianificazione strategica: le nuove sfide delle università europee*.
- March 7, Cyrill Stachniss, University of Freiburg, *Articulated Models for Mobile Manipulation Tasks*.

- March 7, Maren Bennewitz, University of Freiburg, *Humanoid Robot Navigation in Complex Indoor Environments*.
- March 24, Paola Festa, Università degli Studi di Napoli "Federico II", *An introduction to metaheuristics and approximation algorithms for solving hard combinatorial optimization problems*.
- March 30 - April 1, Léopold Simar, Université Catholique de Louvain, *An introduction on Efficiency and Productivity analysis with an overview on recent developments*.
- April 29, Jean-Paul Laumond, LAAS-CNRS Toulouse, *Robotics: Hephaistos reoffends*.
- May 6, Boris Lau, University of Freiburg, *Online Generation of Kinodynamic Trajectories*.
- May 13, Holger H. Hoos, University of British Columbia, *Programming by Optimisation: Towards a new Paradigm for Developing High-Performance Software*.
- May 19, Thomas Schoen, University of Linköping, *Nonlinear system identification and sensor fusion*.
- May 20, Andreas Karwath, University of Freiburg, *Graphs, Sequences of Graphs, and their Alignment*.
- May 27, Jean-Paul Laumond, LAAS-CNRS Toulouse, *Motion planning: What does it move for?*
- June 7, Jean-Paul Laumond, LAAS-CNRS Toulouse, *On human and humanoid locomotion*.
- June 24, Fabio Patrizi, Imperial College London, *Verification of Deployed Artifact Systems via Data Abstraction*.
- July 4, Antonio Bicchi, Università di Pisa, *The geometry of haptic synergies in artificial touch and manipulation*.
- July 4, Paolo Salaris, Università di Pisa, *From optimal synthesis to optimal visual servoing for autonomous vehicles*.
- September 8, Stephen Kimani, CSIRO Tasmanian ICT Centre, *Designing for Healthy Living*.
- September 19, Rina Dechter, University of California at Irvine, *Recent Advances in Solving Combinatorial Optimization Tasks over Graphical Models*.
- September 20, Nicolas Mansard, LAAS-CNRS Toulouse, *Task function for dynamic animation and recognition*.
- September 20-22, *25th International Symposium on Distributed Computing (DISC)*.

- September 29, IBM Faculty Award *Analisi di processi di business basati su artefatti.*
- September 29, Rick Hull, IBM Watson Research Center, *Artifact-centric business processes.*
- September 29, Giuseppe De Giacomo, Sapienza Università di Roma, *Artifact-centric process verification.*
- September 29, Claudio Leporelli, Sapienza Università di Roma, *Aspetti economici e organizzativi dei processi di business.*
- October 3-7, W.M. Wonham, University of Toronto, *Supervisory control of discrete-event systems.*
- October 11, W.M. Wonham, University of Toronto (Canada), *From linear systems to discrete-event systems.*
- November 10, NAO European Tour.
- November 23, Philippe Laredo, Université Paris-Est and University of Manchester, *Nanotechnologies as a new type of general purpose technology: implications for market development.*
- November 24, Francesco Belardinelli, Imperial College London, *First-order Languages for the Specification of Multi-agent Systems.*
- November 30, Ahmed Chemori, CNRS LIRMM Montpellier, *Control of an underactuated mechanical systems for stabilization and stable limit cycle generation: from simulation to real-time experiments.*
- December 1, *EU Robotics Week: Robotics@DIS.*
- December 7, *Incontro in onore di Giorgio Ausiello in occasione del suo settantesimo compleanno.*

In addition, DIAG organizes a series of seminars in cooperation with the Department of Computer Science (DI). Below is the list of the seminars of the series.

- March 7 at DIAG, Prasad Chebolu, University of Liverpool, *Algorithms for Random Graphs and Counting.*
- June 20 at DIAG, Guido Schaefer, CWI & VU University Amsterdam, *On the Inefficiency of Altruistic Games.*
- September 12 at DIAG, Vangelis Markakis, Athens University of Economics and Business, *Approximation Algorithms and Mechanism Design for Minimax Approval Voting.*

## 2.8 Awards and Individual Grants

- Laura ASTOLFI, HBM2011 Trainee Abstract Travel Awards at the 17th Human Brain Mapping Annual Meeting, June.
- The 2011 edition of the *International Workshop on Graph algorithms and Applications* (co-located with the *38th International Colloquium on Automata, Languages and Programming*) was is in honor of Giorgio AUSIELLO in the occasion of his 70th birthday, July.
- Jlenia TOPPI, 2nd best poster award at the 8th Summer School on Biomedical Signal Processing, July.
- Daniele NARDI, President of the RoboCup Federation, July.
- Maurizio LENZERINI, Elected Member of “Academia Europaea - The Academy of Europe”, September.
- Camil DEMETRESCU and Andrea RIBICHINI, Distinguished Paper Award at the Annual ACM Conference on Object-Oriented Programming, Systems, Languages & Applications (OOPSLA 2011) for the paper: “Reactive imperative programming with dataflow constraints” by Camil Demetrescu, Irene Finocchi, and Andrea Ribichini, October.
- Marco CASTRUCCI and Andrea SIMEONI, “Extension of the OpenFlow framework to foster the Software Defined Network paradigm in the Future Internet”, *Premio Orio Carlini* 2011 from GARR on the topic “Future Internet e tecnologie abilitanti al lavoro collaborativo in rete”, October.
- Fabrizio D’AMORE, Fellow of the *Global Cyber Security Center*, December.
- Giuseppe DE GIACOMO, University of Melbourne Miegunyah Distinguished Visiting Fellowship.



## 3 Research

### 3.1 Algorithm Design and Engineering

#### Research lines:

- Principles of Design and Analysis of Algorithms
- Experimental Algorithmics
- External Memory and Streaming Algorithms for Massive Data Processing
- Incremental Algorithms and Dynamic Data Structures
- Approximation and On-line Algorithms
- Algorithmic Game Theory

**Members:** Giorgio Ausiello (leader), Fabrizio D'Amore, Camil Demetrescu, Stefano Leonardi, Alberto Marchetti-Spaccamela, Umberto Nanni.

**PhD Students:** Donatella Firmani.

**Post Docs:** Aris Anagnostopoulos, Vincenzo Bonifaci, Luigi Laura, Andrea Ribichini, Piotr Sankowski.

Research activity regarding design and engineering of computer algorithms and computational complexity analysis has been developed at DIAG since when the Department has been created in the early Eighties. In the first years the emphasis has been on theoretical aspects such as those related to the notion of approximation preserving reductions among optimization problems and the classification of optimization problems based on their approximability properties. Subsequently, research activities have evolved in various directions according to the evolution of information technology and of application domains. New emerging topics have been addressed such as dynamic graph algorithms, on line algorithms, external memory, and streaming algorithms for massive data sets. Also the emphasis of the approach has changed moving from traditional worst case analysis to experimental performance analysis.

The most relevant recent results include contributions in the following areas:

- Principles of Design and Analysis of Algorithms: re-optimization techniques for combinatorial problems, models of computation for very large data sets;
- Experimental Algorithmics: implementation and engineering of advanced algorithms and data structures for graph problems;
- External Memory and Streaming Algorithms for Massive Data Processing: external-memory and streaming algorithms for very large graph problems;

- Incremental Algorithms and Dynamic Data Structures: incremental algorithms for path problems in graphs;
- Approximation and On-line Algorithms: scheduling algorithms, algorithms for metabolic networks, vehicle routing, approximation algorithms for rent-or-buy network design problems, on-line algorithms for stochastic optimization problems such as Steiner tree and set cover under several models;
- Algorithmic Game Theory: quality of strong equilibria in network formation games under restricted communication model.

In the future we plan to tackle fundamental problems arising in emerging applications involving the analysis and optimization of software systems and networks, real-time systems, scheduling and resource allocation. Special emphasis will be given to problems on very large data sets and multi-core platforms. In particular, our research goals include:

- External Memory and Streaming Algorithms for Massive Data Processing: external-memory and streaming algorithms for problems arising in the dynamic analysis of large software systems and networks. Among other goals, we plan to investigate novel approaches to performance profiling and optimization based on provably efficient streaming techniques;
- Incremental Algorithms and Dynamic Data Structures: we will study efficient incremental change propagation techniques for constraint-based systems on multi-core platforms;
- Approximation and On-line Algorithms: we aim at investigating the complexity and the approximability of combinatorial resource allocation problems, with a focus on problems arising from the scheduling of recurrent tasks in real-time systems. In particular, we aim at the design and analysis of efficient tests of feasibility for the scheduling of tasks on multiprocessor platforms. We will push further the study of on-line algorithms for stochastic optimization problems. We'll also consider the simultaneous approximation on several objective functions and on network instances.

#### Projects:

- *AlgoDEEP: Algorithmic Challenges for Data-intensive Processing on Emerging Computing Platforms* - March 2010, September 2012 - PRIN MIUR.
- *MAINSTREAM: Algorithms for massive information structures and data streams* - May 2007, February 2009 - PRIN MIUR.
- *AEOLUS: Algorithmic principles for building overlay computers* - December 2005, December 2010 - EU FP6 FET.
- *FRONTS: Foundations of Adaptive Networked Societies of Tiny Artefacts* - March 2008, March 2012 - EU FP7 FET.

- *SIMBIOSI: INRIA associated team* - January 2009, January 2011 - INRIA.

### Journals

- [1] Anagnostopoulos A., Kumar R., Mahdian M., and Upfal E. Sorting and selection on dynamic data. *Theoretical Computer Science*, 412(24):2564–2576, 2011.
- [2] Bonifaci V., Korteweg P., Marchetti-Spaccamela A., and Stougie L. The distributed wireless gathering problem. *Theoretical Computer Science*, 412(8-10):633–641, 2011.
- [3] Bonifaci V., Korteweg P., Marchetti-Spaccamela A., and Stougie L. Minimizing flow time in the wireless gathering problem. *ACM Transactions on Algorithms*, 7(3):1–20, 2011.
- [4] Chan H.-L., Edmonds J., Lam T. W., Lee L.-K., Marchetti-Spaccamela A., and Pruhs K. Nonclairvoyant speed scaling for flow and energy. *Algorithmica*, 61(3):507–517, 2011.
- [5] Frandsen G. and Sankowski P. Dynamic normal forms and dynamic characteristic polynomial. *Theoretical Computer Science*, 412(16):1470–1483, 2011.
- [6] Nanni U., Spila A., Riondino S., Valente M., Somma P., Iacoboni M., Alessandrini J., Ferroni P., Roselli M., and Guadagni F. Rfid as a new ict tool to monitor specimen life cycle and quality control in a biobank. *International Journal of Biological Markers*, 26(2):129–135, 2011.

### Books

- [7] Marchetti-Spaccamela A. and Segal M., editors. *Theory and Practice of Algorithms in (Computer) Systems - First International ICST Conference, TAPAS 2011, Rome, Italy, April 18-20, 2011. Proceedings*, volume 6595 of *Lecture Notes in Computer Science*. Springer, 2011.

### Conference Proceedings

- [8] Ausiello G., Boria N., Giannakos A., Lucarelli G., and Paschos V. On line maximum k-coverage. In *Proceedings of the 18th International Symposium on Fundamentals of Computation Theory (FCT)*, pages 181–192, 2011.
- [9] Baruah S., Bonifaci V., D’Angelo G., Marchetti-Spaccamela A., van der Ster S., and Stougie L. Mixed-criticality scheduling of sporadic task systems. In *Proceedings of the 19th Annual European Symposium on Algorithms*, pages 555–566, 2011.
- [10] Cygan M., Grandoni F., Leonardi S., Mucha M., Pilipczuk M., and Sankowski P. Approximation algorithms for union and intersection covering problems. In *Proceedings of the IARCS annual conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS)*, pages 28–40, 2011.

- [11] D’Elia D., Demetrescu C., and Finocchi I. Mining hot calling contexts in small space. In *Proceedings of the 32nd ACM SIGPLAN Conference on Programming Language Design and Implementation (PLDI)*, pages 516–527, 2011.
- [12] Demetrescu C., Finocchi I., and Ribichini A. Reactive imperative programming with dataflow constraints. In *Proceedings of the 26th ACM SIGPLAN Conference on Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA)*, pages 407–426, 2011.
- [13] Italiano G., Nussbaum Y., Sankowski P., and Wulff-Nilsen C. Improved minimum cuts and maximum flows in undirected planar graphs. In *Proceedings of the 43rd ACM Symposium on Theory of Computing (STOC)*, 2011.
- [14] Marchetti-Spaccamela A. Structures and hyperstructures in metabolic networks. In *Proceedings of the 37th International Workshop on Graph-Theoretic Concepts in Computer Science (WG)*, pages 1–4, 2011.

#### **Submitted papers, technical reports and others**

- [15] Bonifaci V. and Marchetti-Spaccamela A. Feasibility analysis of sporadic real-time multiprocessor task systems. *Algorithmica*, 63(4):763–780, 2012.
- [16] Coppa E., Demetrescu C., and Finocchi I. Input-sensitive profiling. To appear in *Proceedings of the 33rd ACM SIGPLAN Conference on Programming Language Design and Implementation (PLDI)*, 2012.
- [17] Alimonti P., Feuerstein E., Laura L., and Nanni U. Linear time analysis of properties of conflict-free and general petri nets. *Theoretical Computer Science*, 412(4).
- [18] Bonifaci V., Marchetti-Spaccamela A., and Stiller S. A constant-approximate feasibility test for multiprocessor real-time scheduling. *Algorithmica*, 62(3).

### **3.2 Artificial Intelligence and Knowledge Representation**

#### **Research lines:**

- Description Logics
- Reasoning about Actions
- Semantic Web
- Logics for AI
- Cognitive Robotics

**Members:** Luigia Carlucci Aiello (leader), Giuseppe De Giacomo, Maurizio Lenzerini, Paolo Liberatore, Domenico Lembo, Daniele Nardi, Riccardo Rosati, Fabio Patrizi, Antonella Poggi.

**PhD Students:** Riccardo De Masellis, Paolo Felli, Valerio Santarelli, Cristina Civili, Domenico Fabio Savo, Gabriele Randelli.

**Post Docs:** Marco Ruzzi, Matteo Leonetti.

Research in Artificial Intelligence at DIAG started in the early 80s and established this research group as one of the most prominent ones in the field of logic-based knowledge representation and automated reasoning. Research has been conducted in many areas, with several outstanding results. The research lines presently active are described in the following.

Description Logics (DL) form a family of Logic-based Knowledge Representation Languages which allow for modeling an application domain in terms of objects, concepts and relationships between concepts, and for reasoning about them. They are widely used in several areas, including ontology engineering, Semantic Web, and information integration. The research at DIAG on DL has a long tradition, and focuses on many relevant aspects, including algorithms for automated reasoning, trade-off between expressive power and computational complexity of reasoning, query answering in DL knowledge bases, adding both monotonic and non-monotonic rules to DL. In the future, the work on DL will both continue along the above mentioned lines and focus on dynamic aspects, such as update and revision of DL knowledge bases, and reasoning about programs expressed on such knowledge bases.

Reasoning about Actions concerns the theory and the implementation of agents that reason, act and perceive in changing, incompletely known, and unpredictable environments. Such agents must have higher level cognitive functions that involve reasoning, for example, about goals, actions, when to perceive and what to look for, the cognitive states of other agents, time, collaborative task execution, etc. Our research on Reasoning about Actions focuses on several aspects, including: foundations of theory of actions; various forms of planning for sophisticated dynamic properties, e.g., expressed in LTL; high-level agent programs, like ConGolog based on the Situation Calculus; agent behavior synthesis and composition. This research is also related with, and applied to, other areas, such as cognitive robotics, multi-agent/multi-robot systems, software service modeling, execution and composition, high-level programs over ontologies and data sources.

The Semantic Web aims at intelligent information processing by creating and connecting a web of machine-understandable information. Our research in this area mainly focuses on representation languages for the Semantic Web, in particular, ontology specification languages. A remarkable outcome of our research in this area is the standardization (October 2009) of the OWL 2 QL ontology specification language by the World Wide Web Consortium. OWL 2 QL directly derives from DL-Lite, a family of ontology formalisms which we proposed and studied in our recent research in this field.

Another research strand is focused on belief revision (how to revise knowledge when new information is given), default logic (how to draw inference in case precise information is lacking), and automated planning.

Finally, one research stream specifically addresses action representation and world modeling in intelligent robots, also in connection with the work in Multi-Agent and

Multi-Robot Systems. The goal is to bridge the gap between the theoretical work in knowledge representation and reasoning and the design of intelligent robotic systems.

### Projects:

- *Networked mixed human robot teams for applications in emergency scenarios*, € 13.500, Sapienza Finanziamento Progetti di Ricerca Anno 2010.
- *UK Royal Society International Joint Project 2009/R2 on “Web services automatic synthesis through ATL symbolic model checking”*. Giuseppe De Giacomo, joint with Alessio Lomuscio, Imperial College London;
- *Australian Research Council (ARC) Competitive Research Grant - Discovery Project DP120100332 “Optimisation of embedded virtual complex systems by re-using a library of available components”*, Giuseppe De Giacomo, joint with Sebastian Sardina of RMIT and Maurice Pagnucco of Univ. of Sidney (2012-2014).
  - *Joint project with IBM : “Sviluppo di una ontologia in ambito bancario”*, Maurizio Lenzerini, June 2010 - May 2012.
  - *Joint project with DBConsulting S.p.A.: “Sviluppo di ontologia in ambito debito pubblico ed uso di tecnologie semantiche per l’accesso ai dati”*, Maurizio Lenzerini, January 2011 - September 2011
  - *Speaky Acutattile*, Ministero dello Sviluppo Economico (Industria 2015), Luigia Carlucci Aiello, Daniele Nardi, June 2011 - June 2014
  - *Speaky for Robots*, CEE FP7, ECHORD IP, Daniele Nardi, November 2011 - April 2013

### Journals

- [1] Calvanese D., De Giacomo G., Lembo D., Lenzerini M., Poggi A., Rodriguez-Muro M., Rosati R., Ruzzi M., and Savo D. F. The mastro system for ontology-based data access. *Semantic Web Journal*, 2(1):43–53, 2011.
- [2] Ziparo V., Iocchi L., Lima P., Nardi D., and Palamara P. Petri Net Plans - A framework for collaboration and coordination in multi-robot systems. *Autonomous Agents and Multi-Agent Systems*, 23(3):344–383, 2011.

### Chapters in Books

- [3] Aiello L. C., Nardi D., Randelli G., and Scalzo C. Suppose you have a robot. In Lakemeyer G. and McIlraith S., editors, *Knowing, Reasoning and Acting: Essays in Honor of Hector J. Levesque.*, pages 27–46. College Publications, London, UK, 2011.
- [4] Calvanese D., De Giacomo G., Lenzerini M., and Rosati R. Actions and programs over description logic knowledge bases: A functional approach. In Lakemeyer G. and McIlraith S., editors, *Knowing, Reasoning and Acting: Essays in Honor of Hector J. Levesque.* College Publications, London, UK, 2011.

- [5] De Giacomo G. and Pagnucco M. Chronolog: It's about time for golog. In Lake-meyer G., , and McIlraith S., editors, *Knowing, Reasoning and Acting: Essays in Honor of Hector J. Levesque*. College Publications, London, UK, 2011.

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- [6] De Giacomo G., Lesperance Y., and Muise C. Agent supervision in situation-determined congolog. In *Proceedings of the 9th International Workshop on Non-monotonic Reasoning, Action and Change (NRAC 2011)*, 2011.
- [7] De Giacomo G., Levesque H., and Lesperance Y. Efficient reasoning in proper knowledge bases with unknown individuals. In *Proceedings of the 22nd International Joint Conference on Artificial Intelligence (IJCAI 2011)*, 2011.
- [8] Hu Y. and De Giacomo G. Generalized planning: Synthesizing plans that work for multiple environments. In *Proceedings of the 22nd International Joint Conference on Artificial Intelligence (IJCAI 2011)*, 2011.
- [9] Hu Y. and De Giacomo G. A generic framework and solver for synthesizing finite-state controllers. In *Proceedings of the AAAI 2011 Workshop on Generalized Planning (GenPlan 2011)*, 2011.
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### 3.3 Combinatorial Optimization

**Research lines:**

- Polyhedral Combinatorics
- Graph theory and Optimization
- Telecommunication Network Design
- Scheduling and Job-shop Scheduling
- Computational biology and polymer sequencing problems;
- Satisfiability of propositional logic formulae;
- Data mining and classification;
- Machine learning;

**Members:** Renato Bruni, Carlo Mannino, Antonio Sassano (leader).

**Post-docs:** Silvia Canale, Fabio d'Andreagiovanni, Carla Michini.

Combinatorial Optimization searches for an optimal set of objects into a finite (but large) collection of sets. Graph Theory, Integer Programming and Polyhedral Combinatorics are the key methodological tools in this area.

The activity of the Combinatorial Optimization Group at DIAG dates back to the early '90s and has been focused both on the theoretical properties of combinatorial structures and the use of sophisticated algorithmic tools to solve real-life problems.

In particular, major research has been carried out on the following subjects: polyhedral properties of set covering, stable set and p-median problems; perfect graph theory, exact and heuristic algorithms for stable set and set covering; algorithms for coloring and frequency assignment problems; decomposition algorithms and reformulations for wireless network design problem; fixed network design and survival network design; algorithms for job-shop scheduling and railway traffic management; algorithms for satisfiability of logic formulae, algorithms for matching.

The group is currently cooperating with the University of Maastricht, University of Oslo, Università di Roma Tor Vergata, Università dell'Aquila, Università di Lecce, Politecnico di Milano, Università del Sannio, Texas Tech University, ZIB Berlin. The group has been involved in a large number of national and international projects.

In the last 10 years the group has developed methods and algorithms aimed at the *optimal design of broadcasting networks*. The scientific leadership gained in this field has motivated a stable cooperation with the *Italian Authority for Telecommunication* and the decisive contribution of the group to the design of the national (analog and digital) TV and radio plans.

The current key members of the group have published more than 100 journal papers, several book chapters, and two books. Moreover they are or have been editors of some

of the main journals in the field of Operations Research and Optimization. Recently the group received a prestigious international award from the Association of European Operational Research Societies (EPA 2009).

In addition to further development of on-going research project, our future activities involve the study of optimization algorithms to rescue or prevent financial crises; algorithms for weighted matching and stable set problems; polyhedral properties of the stable set polyhedron and of interval and staircase matrices; optimization techniques for boosting problems in machine learning; purely combinatorial approaches to wireless network design; railway traffic control and optimization on single-track networks.

#### Projects:

- *APICE - Algoritmi per la Pianificazione Integrata e Controllo di reti wireless Eterogenee*, MIUR project n. 2878.
- *Metodi di ottimizzazione su larga scala nelle telecomunicazioni*, PRIN 2008 project, n. 2008LLYXFS.

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#### Books

- [2] Bruni R. (ed.), *Mathematical Approaches to Polymer Sequence Analysis and Related Problems*, Springer, New York, 2011, ISBN 978-1-4419-6799-2.

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- [15] Canale S., De Santis A., Iacoviello D., Pirri F. and Sagratella S., Texture Analysis and Pattern Recognition in X-band SAR Images for Urban Forestry, In *Proc. of the 2011 VIPIMAGE Workshop: Satellite image analysis for environmental risk assessment*, 2011.

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### 3.4 Computer Networks and Pervasive Systems

#### Research lines:

- Wireless and Sensor Networks
- Networks of Resource Constrained Devices
- Streaming Applications over Wireless
- Network Coding
- Self-\* Protocols and Systems

**Members:** Roberto Beraldi, Alberto Marchetti Spaccamela (leader), Leonardo Querzoni, Andrea Vitaletti.

**PhD Students:** Khalil M.H. Al Massri, Lorenzo Bergamini, Ugo Colesanti, Francesco Ficcarola, Luca Filippini, Suzanne Van De Ster .

The miniaturization of electronic devices and the advancements in telecommunications, make it possible the realization of ubiquitous pervasive systems, i.e. systems in which information processing has been thoroughly and transparently integrated into everyday objects and activities. These systems are composed of heterogeneous tiny artefacts such

as wireless sensor nodes, RFID and NFC tags and readers, mobile phones etc. Such devices are often constrained in their computational and energy resources and are organized in large networks that do not rely on wired infrastructures.

The realization of such systems requires new solutions in the design of algorithms and protocols for wireless ad hoc networks connecting large numbers of device. Such networks might be very large and operate in a highly dynamic environment: sensor nodes move, enter and exit the system and are prone to faults, while communication links are often noisy and unreliable. As a consequence, adopted solutions should be simple, efficient, and robust; in particular, since energy is usually provided by batteries, energy efficiency must always be considered as a primary goal. The scale and nature of pervasive systems requires networks able to react to unexpected events and to operate beyond the complete understanding and control of the designer and of the user. In fact, these systems should achieve an appropriate level of self-organization and integration to adapt to continuously changing environments and to cope with unforeseen faults.

Our research focuses on the design, analysis, experimentation and implementation of algorithms and protocols for networks of tiny artefacts. One specific topic of interest is the study of advanced adaptive routing algorithms in ad hoc wireless networks that are efficient and reduce the energy requirements at wireless nodes.

We are also interested in solving complex communications primitives such as service discovery and event-based data diffusion, with the final goal of characterizing sensors networks as a data storage and retrieval. In the future we plan to address security and privacy issues of such networks. In fact the limited available resources requires new techniques and algorithms. We complement our research with experimental work that is based on simulations (using network simulators such as NS2, OMNET++ and Shawn), and on test-beds (e.g. we run a permanent test-bed of wireless sensor network to monitor the ancient roman remains at the basement of DIAG). We are also interested in experimenting our ideas on smart mobile phones, such as the iPhone, in the context of augmented reality and fully decentralized recommendations.

#### **Projects:**

- *Progetto FIRB Italia Israele, Sapienza-Technion Haifa* - July 2007, July 2009 - MIUR FIRB.
- *PANORAMA: Coordinated Action on Pervasive Adaptation* - February 2008, January 2011 - EU FP7 Coordinated action.
- *FRONTS: Foundations of Adaptive Networked Societies of Tiny Artefacts* - February 2008m, January 2011 - EU FP7 IP.
- *AEOLUS: Algorithmic principles for building overlay computers* - September 2006, February 2010 - EU FP6.

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- [3] Chatzigiannakis I., Mylonas G., and Vitaletti A. Urban pervasive applications: Challenges, scenarios and case studies. *Computer Science Review*, 5(1):103–118, 2011.
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## Books

- [5] Demetrescu C. and Halldórsson M. M., editors. *Algorithms - ESA 2011 - 19th Annual European Symposium, Saarbrücken, Germany, September 5-9, 2011. Proceedings.*, volume 6942 of *Lecture Notes in Computer Science*. Springer, 2011.

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- [6] Bergamini L., Becchetti L., and Vitaletti A. Privacy-preserving environment monitoring in networks of mobile devices. pages 179–191. Springer, 2011.
- [7] Colesanti U. M., Santini S., and Vitaletti A. Dissense: An adaptive ultralow-power communication protocol for wireless sensor networks. In *International Conference on Distributed Computing in Sensor Systems and Workshops (DCOSS)*, pages 1–10, 2011.
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- [9] Schiano di Zenise M., Vitaletti A., and Argles D. A user-centric approach to ecertificate for electronic identities (eids) management in mobile environment. In *World Congress on Internet Security (WorldCIS)*, pages 198–203, 2011.

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- [10] Becchetti L., Filipponi L., and Vitaletti A. Privacy support in people-centric sensing. *Journal of Communications*, 2012.

### 3.5 Computer Vision, Computer Graphics, and Perception

**Research lines:**

- Augmented Reality and Computer Animated Virtualization
- Human Motion Analysis, Gesture Recognition, Physics based methods
- Attention, Recognition and Scene Understanding
- Auditory Perception
- Geometric Modeling and Multi-view Geometry
- Pattern Recognition
- Modeling Uncertainty in Knowledge Representation
- Multimodal Human Robot Interaction

**Members:** Alberto De Santis, Daniela Iacoviello, Luca Iocchi, Fiora Pirri (leader), Marco Schaerf.

**PhD Students:** Bruno Cafaro, Andrea Carbone, Mario Gianni, Letizia Marchegiani, Alessio Pascucci, Matia Pizzoli, Simone Sagratella.

**Post Docs:** Panagiotis Papadakis.

Research activity in the fields of Computer Vision, Computer Graphics and Perception has been developed at DIAG since 1998. We focused on Augmented Reality, Computer Animated Virtualization, developing several prototypes based on the augmented reality paradigm, mainly with applications to tourism multimedia production. We also focused on Human Motion Analysis, Gesture Recognition, Interpretation and Simulation and Physics based Methods, investigating both simulation and interpretation models. On the simulation side, we developed physically accurate models of human face expressions, based on face features detection and motion analysis. On the recognition and interpretation side, we developed an original method for people recognition and identification based on features data structures, taking into account face expressions. Finally, we devised a method for action sequence deduction, from observations, by modelling and grouping perceived movements into actions. In Auditory Perception field, we built a system for people identification in a conversation scenario integrating Bayesian based voice recognition, separating background and foreground audio, with face recognition.

Recognition and Scene Understanding has mainly concentrated on attention, a gaze machine for specific experiments on visual localization and recognition has been created. This also allow us to model both bottom-up and top-down attention and consequently to provide statistical models for motion, grouping and natural images understanding.

Concerning Geometric Modeling and Multi-view Geometry we developed multi-view methods for the gaze machine and for scene reconstruction. Scene understanding has

also been developed according to a specific model of natural images. Research issues, specifically in vision, have also led the developing a new segmentation method and the description of an innovative surveillance system, that is already at work in Venice.

A good deal of research activity have also concerned methodological aspects of medical images; the discrete level set theory was studied and applied for robust real time eye tracking for computer interface. Moreover texture analysis was used for microscopic liver tissue images and mammography, whereas dental micro CT images were analyzed to yield information for stress analysis for damage identification in a human premolar tooth.

### Projects:

- *NIFTi - Natural human-robot cooperation in dynamic environments* - 2010, 2014 - EU FP7 IP.
- *SARFIRE - Spaceborn SAR imagery and environmental data fusion for the dynamical evaluation of land regions susceptibility to fire* - 2010, 2012 - ASI Cosmo Sky Med.

### Journals

- [1] Andreaus U., Colloca M., Iacoviello D., Coupling image processing and stress analysis for damage identification in a human premolar tooth. *Computer Methods and Programs in Biomedicine*, 13(2):61-73, 2011.
- [2] Andreaus U., Colloca M., Iacoviello D., Pignataro M., Optimal Tuning PID control of adaptive materials for structural efficiency. *Structural and Multidisciplinary Optimization*, 43(1):43-59, 2011.

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- [3] Iacoviello D., A discrete level set approach for texture analysis of microscopic liver images. In *Computational Vision and Medical Image Processing: Methods and Applications*, Springer, pp. 113-124, 2011.
- [4] Espina M., Grech R., De Jager D., Remagnino P., Iocchi L., Marchetti L., Nardi D., Monekosso D., Nicolescu M., King C., Multi-robot Teams for Environmental Monitoring. In *Innovations in Defence Support Systems 3*, Springer, pp. 183-209, 2011.

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- [6] Mancas M., Pirri F. and Pizzoli M., Human-motion saliency in multi-motion scenes and in close interaction. *Proceedings of the 9th International Gesture Workshop on Gesture in Embodied Communication and Human-Computer Interaction*, Athens, GR, 2011.



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- [8] Pirri F., Pizzoli M., Rigato D. and Shabani R., 3D Saliency Maps. *Computer Vision and Pattern Recognition Workshops (CVPRW)*, Colorado Springs, CO, USA, 2011.
- [9] Khambhaita H., Kruijff G., Mancas M., Gianni M., Papadakis P., Pirri F., Pizzoli M., Help me help you: how to learn intentions, actions and plans. *AAAI Spring Symposium Help Me Help You: Bridging the gaps in Human-Agent Collaboration*, Palo Alto, CA, USA, 2011.
- [10] Santis C., Iacoviello A., Pirri F., Sagratella S., Dini L., Cosmo-Skymed Constellation: SAR images and anthropic factors for learning a susceptibility fire map. *In Proceedings of ESA-EUSC-JRC, Image Information Mining. Geospatial Intelligence from Earth Observation, IEEE-GRSS*, Italy, 2011.
- [11] De Santis A., Iacoviello A., Pirri F., Sagratella S., S. High-Resolution SAR images for fire susceptibility estimation in urban forestry. *ISPRS Workshop on High-Resolution Earth Imaging for Geospatial Information*, Hannover, Germany, 2011.
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- [20] , Bloisi D., Iocchi L., Fiorini M., Graziano G., Automatic Maritime Surveillance with Visual Target Detection. *Proceedings of the International Defense and Homeland Security Simulation Workshop (DHSS)*, Rome, Italy, 2011.
- [21] Dodds R., Iocchi L., Guerrero P., Ruiz J., Benchmarks for Robotic Soccer Vision. *RoboCup Symposium (CD-ROM Proceedings)*, 2011.
- [22] Iocchi L., Monekosso D., Nardi D., Nicolescu M., Remagnino P., Valera-Espina M., Smart Monitoring of Complex Public Scenes. *2011 AAAI Fall Symposium Series*, USA, 2011.

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### **3.6 Continuous Optimization**

#### **Research lines:**

- Nonlinear Optimization
- Derivative Free Methods
- Global Optimization
- Semidefinite Programming
- Variational Inequalities
- Mixed Integer Nonlinear Programming
- Game Engineering
- Neural Networks and Support Vector Machines

- Engineering Design Optimization
- Resource allocation in communication networks

**Members:** Gianni Di Pillo (leader), Francisco Facchinei, Luigi Grippo, Stefano Lucidi, Laura Palagi, Massimo Roma.

**PhD Students:** Stefania De Angelis, Marianna De Santis, Andrea Ianni, Lorenzo Lampariello, Vittorio La Torre, Andrea Manno, Olimpia Ottaviani, Mauro Piacentini, Simone Sagratella, Serena Teobaldo.

**Post Docs:** Francesco Rinaldi.

Research in continuous optimization has been active at DIAG since its foundation. Early research was essentially devoted to the theory of exact penalization and to the development of algorithms for the solution of constrained nonlinear programming problems through unconstrained techniques. Significant early contributions were also given in the field of unconstrained optimization, with the introduction of non monotone line searches, non monotone globalization strategies and convergent derivative-free line search techniques. The Continuous Optimization group later expanded into an active and highly valued optimization research team with a wide range of interests.

The following areas are object of current research.

- Exact penalty and augmented Lagrangian methods, still constituting the founding block of many optimization methods and a springboard for many of the studies of the group.
- Non-monotone methods and decomposition techniques for the solution of difficult large-scale nonlinear optimization problems and nonlinear equations.
- Preconditioning Newton-Krylov methods in nonconvex large scale optimization, which is an important tool for efficiently solving large difficult problems.
- Derivative-free algorithms, of special interest in many engineering applications where even the calculation of function values is problematic and very time-consuming.
- Global optimization, which is an essential tool for solving problems where local non-global solutions may be meaningless.
- Semidefinite programming, that plays an essential role in the development of efficient algorithms for solving relaxations of non-convex and integer problems.
- Finite dimensional variational inequalities and complementarity problems, which often arise in modelling a wide array of real-world problems where competition is involved.

- Generalized Nash equilibrium problems, which are emerging as a winning way of looking at several classical and non-classical engineering problems.
- Training methods for neural networks and support vector machines, for constructing surrogate models of complex systems from sparse data through learning techniques.
- Mixed Integer Nonlinear Programming (MINLP) problems that combine combinatorial aspects with nonlinearities.

The Continuous Optimization group interacts intensively with many other research groups, both in the academic and industrial world, in an ongoing cross-fertilization process. This process led to several innovative applications in such different fields as:

- Design of electro-mechanic devices.
- Development of electromagnetic diagnostic equipments.
- Power allocation in TLC.
- Shape optimization in ship design.
- Multiobjective optimization of nanoelectronic devices.
- Sales forecasting in retail stores.

Moreover, as a spin-off of the activity carried out in applied optimization, the company ACTOR (Analytics, Control Technologies and Operations Research) has been founded. ACTOR is participated by Sapienza University, by researchers of the Department and by the private company ACT Solutions. The main aim of ACTOR is to develop and commercialize advanced optimization models and methods to be employed in the production and management of goods and services.

#### Projects:

- German-Italian research collaboration program *Programma Vigoni - Bando 2010* with the Technische Universität Dortmund, Fakultät für Mathematik.
- *MODERN: MOdeling and Design of Reliable Nanoelectronics devices* - March 2009, February 2012 - ENIAC European Nanoelectronics Initiative Advisory Council.
- *MANON: Methods for Advanced multi-objective optimization of complex NANoscale circuits* - April 2010, March 2012 - UE FP7/PEOPLE.

#### Journals

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- [3] Dreves A., Facchinei F., Kanzow C., and Sagratella S. On the solution of the KKT conditions of generalized Nash equilibrium problems. *SIAM Journal on Optimization*, 21:1082–1108, 2011.
- [4] Facchinei F. and Lampariello L. Partial penalization for the solution of generalized Nash equilibrium problems. *Journal of Global Optimization*, 50:39–57, 2011.
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- [15] Facchinei F., Fischer A., and Herrich M. An LP-Newton method: Nonsmooth equations, KKT systems, and nonisolated solutions. Technical Report MATH-NNM-2011, Technische Universitat Dresden, Institut fur Numerische Mathematik. Submitted to *Mathematical Programming*.
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### 3.7 Data Management and Service-Oriented Computing

#### Research lines:

- Data Integration and Exchange
- Ontology Based Information Systems
- Data Warehousing, Data Quality and Data Cleaning
- Digital Records Management and Preservation
- Process and Workflow Management
- Service Modeling
- Service Synthesis and Composition

**Members:** Tiziana Catarci, Giuseppe De Giacomo, Domenico Lembo, Maurizio Lenzerini (leader), Massimo Mecella, Fabio Patrizi, Antonella Poggi, Riccardo Rosati, Silvio Salza.

**PhD Students:** Mario Caruso, Cristina Civili, Riccardo De Masellis, Claudio Di Ciccio, Floriana Di Pinto, Paolo Felli, Francesco Leotta, Andrea Marrella, Alessandro Russo, Valerio Santarelli, Domenico Fabio Savo.

Our interest in Data Management dates back to the '80s, when the main research topics were conceptual modeling and schema integration, now evolved into Information Integration and Data Exchange. Information integration is the problem of combining the data residing at different heterogeneous sources, and providing a virtual unified view of these data, called global schema, which can be queried by the users. Data Exchange focuses instead on the problem of materializing the global schema according to the data retrieved from the sources. Both (virtual) data integration and data exchange have been recently studied in the context of a peer-to-peer (P2P) data management, where autonomous systems (peers) export data in terms of their own data schema, and import data from other peers to which they are connected through semantic mappings. Other Data Management topics related to Information Integration are also investigated, including Ontology-based Information Systems, View-based Query Processing, Data Quality, Data Cleaning, Record Matching and Instance Reconciliation, and Mobile Data Access.

Our research interests include several aspects of Service-Oriented Computing, and its relationship with Data Management. Services in our context are autonomous, platform-independent computational elements that can be described, published, discovered, orchestrated and programmed for the purpose of developing distributed interoperable applications. We are particularly interested in service modeling and automatic service composition. In this area, we proposed what in the community is now known as the *Roman model*, and contributing to one of the first solutions to automated service composition. Since its introduction, the Roman model has been studied by several research groups

worldwide, and is one of the key references in the formal approaches to automated service composition. We have also studied Service Synthesis, as well as Process and Workflow Management, with a special focus on principles and techniques for modeling the interaction between processes and data.

Data and Service Integration is considered one of the main challenges that Information Technology (IT) currently faces. It is highly relevant in classical IT applications, such as enterprise information management and data warehousing, as well as in scenarios like scientific computing, e-government, and web data management. Our long-term goal is to lay the foundations of a new generation of information integration and service composition systems, whose main characteristics are:

1. posing the semantics of the application domain at the center of the scene,
2. combining the management of data with the management of the processes and services using such data in the organization, and
3. shifting the role of the conceptual model from a design-time to a run-time artifact.

In our vision, the functionalities provided by the system include answering queries posed in terms of the conceptual model by suitably accessing the source data, performing updates over the conceptual models by invoking the appropriate updates on the sources, and realizing complex goals expressed by the client by automatically composing available services.

The basic idea for realizing this goal is to combine principles, methods and techniques from different areas, namely, Data Management, Service-Oriented Computing, Knowledge Representation and Reasoning, and Formal Methods.

### Projects:

- *ACSI - Artifact-Centric Service Interoperation*, June 2010 - May 2013 (EU FP7).
- *GreenerBuildings - An ubiquitous embedded systems framework for energy-aware buildings using activity and context knowledge*, September 2010 - August 2013 (EU FP7).
- *SM4All - Smart homes for all*, September 2008 - August 2011 (EU FP7).
- *COLLECTIVE - Emerging communities for collective innovation: ICT Operational tool and supporting methodologies for SME Associations* January 2010 - December 2012 (EU FP7).
- Project funded by IBM: *Sviluppo di una ontologia in ambito bancario*, June 2010 - May 2012.
- Project funded by Regione Lazio: *Integrazione semantica di dati e servizi per le aziende in rete*, 2011 - 2014.
- Project funded by Telecom Italia: *Sviluppo di ontologia per i "Dynamic Inventory"*, September 2011 - December 2012.



- Open Collaboration Research Agreement W0954341, joint with Rick Hull of IBM T. J. Watson Research Center, NY, on *Data aware business processes and operation, through an artifact-centric approach*, 2009-2012.
- UK Engineering and Physical Sciences Research Council (EPSRC) Project EP/I00520X/1 *Trusted Autonomous Systems*, joint with Alessio Lomuscio, Imperial College London, 2010-2015.
- DesigNet, Industria 2015 “Made in Italy”, 2011 - 2013.
- Project funded by Regione Calabria: PIA COSM Factory, 2010 - 2012.

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### **3.8 Distributed Systems**

#### **Research lines:**

- Smart Environments
- Secure and robust distributed systems
- Resource Sharing Systems
- Event-based Systems
- Distributed Systems Interoperability

**Members:** Roberto Beraldi, Roberto Baldoni (leader), Bruno Ciciani, Francesco Quaglia, Leonardo Querzoni.

**PhD Students:** Leonardo Aniello, Adriano Cerocchi, Giuseppe Antonio Di Luna, Luca Montanari, Marco Platania, Hani Qusa.

**Post Docs:** Silvia Bonomi, Giorgia Lodi.

The Distributed Systems group has developed, in the last ten years, a solid worldwide reputation in the context of theory and practice of distributed, pervasive and p2p computing, middleware platforms, and information systems infrastructures. On these topics, the group has created strong relationships with the most influential research groups in the world. In the last ten years the group has developed several theories and practical experiences that are fully referenced by the research community, including checkpointing, causal ordering theory, distributed replication systems, interceptors, group toolkits, and publish subscribe systems.

The distributed systems group has participated and successfully coordinated several important EU projects in the context of e-government, security and dependability of large scale systems, and protection of the financial infrastructure. It has developed remarkable connections with the major Italian ICT industries and Public Administrations for creating innovative solutions and prototypes transferring the latest results from research area into practice. Our activities are centered in two laboratories: MidLab and the Joint-Lab of Security Research.

MidLab is focussed in research, its primary goal is to support leading-edge research and development on middleware bridging the gap between the latest research results and the current technologies. In particular main MIDLAB targets are the study, the design and analysis of novel middleware platforms able to increase the robustness of information exchanging with respect to reliability, consistency, predictability and security.

The Joint-Lab on Security research, focused on innovation, has the mission to create a critical mass of system researchers at Sapienza Università di Roma with expertise in the development of secure and reliable systems for such domains. The team includes experts in HW design, networking, system and software security, applications and services development.

In addition to the further development of on-going research projects, our future activities will include three important new branches of research: (i) creating solid foundational theory on dynamic aspects of distributed Systems, (ii) methodologies and techniques for massive distributed event processing (iii) middleware for smart spaces (including energy savings in public buildings and intelligent houses). All these topics are indeed rapidly evolving, and the advent of new classes of applications and technologies, such as federation of clouds, airborne networks, smart environments, broad area super-computing, and distributed resource sharing services, is boosting their importance. The theoretical effort is also accompanied by several practical projects in the area of smart environments, namely *SOFIA*, *SM4All* and *Greener Buildings*, and in collaborative security, namely *CoMiFin*, that motivate the foundational research.

The Distributed System group will participate to the Shanghai 2010 with two prototypes developed jointly with the MultiAgent and Multi Robot systems group and the Data Management and Service-Oriented Computing. The group is also organizer of DISC 2011 and of the Master in Interoperability of complex systems for Organizations and Public Administrations.

**Projects:**

- *SM4All, Middleware Platform for Pervasive and Immersive Environments For-ALL* - September 2008, August 2011 - EU Strep.
- *SOFIA, Smart Objects For Intelligent Applications* - January 2009, December 2011 - EU IP ARTEMIS.
- *CoMiFin, Communication Middleware for monitoring financial critical infrastructure* (Project managed by CINI - Consorzio Interuniversitario Nazionale per l'Informatica) - September 2009, March 2011 - EU STREP .
- *DOTS-LCCI, Reliable Middleware systems for Critical Infrastructures based on off-the-shelf components* - March 2010, March 2012 - PRIN MIUR.
- *BLEND, Blending Technologies for Ubiquitous Real-Time Data Access* - June 2010, June 2012 - EUREKA Project.
- *GreenerBuilding, An Ubiquitous Embedded Systems Framework for Energy-aware Buildings using Activity and Context knowledge* - September 2010, August 2013 - EU Strep.
- *Domus Nova, an advanced domotic environment for monitoring the health of elderly and/or risky people* - September 2010, August 2013 - Regional project.
- *Iniziativa Software (ii) – Identification of critical pattern for failure detection in complex distributed systems* (Project managed by CINI - Consorzio Interuniversitario Nazionale per l'Informatica) - January 2010, December 2012 - CINI-FINMECCANICA.

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### 3.9 High Performance and Dependable Computing Systems

**Research lines:**

- Parallel and Distributed Computing Platforms
- Multi-tier Architectures
- Transactional Systems
- Virtualization and Cloud Computing
- Performability Models

**Members:** Bruno Ciciani, Francesco Quaglia.

**PhD Students:** Pierangelo Di Sanzo, Roberto Palmieri, Alessandro Pellegrini, Sebastiano Peluso, Diego Rughetti, Roberto Vitali.

The High Performance and Dependable Computing Systems research group is focused on differentiated aspects of computing and service oriented applications and platforms, spanning from theory to modeling, design and implementation. Significant results have been achieved in

- the definition of frameworks and protocols for dependability in large scale infrastructures, with particular attention to application contexts entailing manipulation of data within (atomic) distributed transactions;
- the design and implementation of high performance computing platforms, with particular interest to discrete event simulation platforms conforming to both proprietary and standardized protocol stacks;
- the definition and validation of accurate performance and dependability models for components/sub-systems forming the core of the aforementioned computing environments.

The vision characterizing the research of this group is based on a strong synergy between theoretical studies and design/development techniques aimed at bridging theory and practice by accurately assessing the viability of research results in environments and application contexts based on current technologies, and in those that can be foreseen via emerging technological trends. Up to now, various open source packages have been released as a concrete indication of the effectiveness of the aforementioned approach.

Several research challenges can be easily envisaged along the paths of Quality-of-Service (QoS) oriented design of systems, as well as the design of autonomic systems embedding self-properties aimed at ensuring/guaranteeing/achieving pre-determined performance and/or dependability levels. The container hosting and framing these challenges will include both traditional system organizations and innovative computing environments relying on systematic use of infrastructure virtualization approaches, such

as cloud computing. Further, we plan to target innovative programming models and paradigms, such as concurrent programming based (a) on updates relying on the (software) transactional memory paradigm, and (b) on transparent and automatic techniques supporting reverse computing schemes as a mean for maintaining causal consistency. The latter will complement the wide set of results already achieved in the context of transparent and efficient (volatile) log/restore schemes in support of both fault-tolerance and optimistic synchronization.

### Projects:

- *ARISTOS: Autonomic Replication of Software Transactional memories* - January 2010, December 2012 - PTDC Portugal/Italy Bilateral Project.
- *INSYEME: INtegrates SYstem for EMERgencies* - November 2007, October 2010 - MIUR FIRB.
- *WEBMINDS: Wide Scale Broadband Middleware for Network Distributed Services* - November 2002, October 2006 - MIUR FIRB.
- *PERF: Performance Evaluation of Complex Systems: Techniques, Methodologies and Tools* - November 2002, October 2006 - MIUR FIRB.
- *Cloud-TM: A Novel Programming Paradigm for the Cloud* - June 2010, May 2013 - FP7 STREP.
- *Transactional Memories: Foundations, Algorithms, Tools, and Applications (EURO-TM)* - fall 2010, fall 2014 - ICT COST Action

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- [7] Di Sanzo P., Ciciani B., Palmieri R., Quaglia F. and Romano P., On the Analytical Modeling of Concurrency Control Algorithms for Software Transactional Memories: The Case of Commit-Time-Locking. To appear in *Performance Evaluation*, already available as on line publication.
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- [9] Peluso S., Didona D. and Quaglia F., Supports for Transparent Object-Migration in PDES Systems. To appear in *Journal of Simulation*, Special Issue on Selected Papers from PADS 2011.
- [10] Peluso S., Ruivo P., Romano P., Quaglia F. and Rodrigues L., When Scalability Meets Consistency: Genuine Multiversion Update-Serializable Partial Data Replication. To appear in *Proceedings of 32nd IEEE International Conference on Distributed Computing Systems, ICDCS '12*. IEEE Computer Society, June 2012.
- [11] Quaglia F. and Santoro A. Transparent Optimistic Synchronization in the High-Level-Architecture via Time Management Conversion. *ACM Transactions on Modeling and Computer Simulation*, pending revision.
- [12] Romano P., Palmieri R. and Quaglia F., Boosting STM Replication via Speculation. In *3rd Workshop on the Theory of Transactional Memory, WTTM '11*, September 2011.
- [13] Romano P., Palmieri R., Quaglia F., Carvalho N. and Rodrigues L., On Speculative Replication of Transactional Systems. *Journal of Computer and System Sciences*, pending revision.

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### 3.10 Human-Computer Interaction

#### Research lines:

- User Interfaces
- Usability Engineering and Accessibility
- Information Visualization
- Automated Personalization and Adaptation in Web-based Learning
- Web-based Social Collaborative Learning

**Members:** Tiziana Catarci (leader), Massimo Mecella, Giuseppe Santucci, Marco Temperini.

**PhD Students:** Claudio Di Ciccio, Andrea Marrella, Shah Rukh Humayoun, Alessandro Russo.

**Post Docs:** Massimiliano de Leoni

Human-Computer interaction (HCI) is the study of the interaction between people (users) and computers. Such an interaction traditionally occurs at the user interface, but its effectiveness is strongly related with the design of the entire interactive system, referring in particular to the way in which it supports the user in achieving her/his goals and executing her/his tasks. Indeed, an important facet of HCI is the securing of the interactive system usability. The research group started working on HCI topics during the late '80s, while developing a visual interface for databases. This pioneering work can be regarded as one of the first and most significant examples of deep analysis and formalization of the interaction between the user and the database, which takes into consideration both usability issues and language related aspects.

Following these lines, the group developed another relevant research topic, namely the definition of adequate visual representations of the databases, in terms of both schema and instances. Note that using a consistent visual representation to depict the information of interest is crucial in order for the user to correctly grasp the database information content. Related with visual representation is information visualization, i.e. the use of computer-based, visual, interactive representations of information with the purpose of making sense out of data, acquire knowledge, discover new information, and effectively present the result.

In the last years we focused on clutter reduction for information visualization analyzing the visual issues associated with the use of density maps focusing on the correct

assignment of visual variable values to a data domain, taking into account its frequency distributions. Other HCI topics are also investigated, including the study of specific usability, accessibility, and adaptivity methodological aspects, the interaction with different realms, e.g. digital libraries, cultural artifacts, mobile and ubiquitous systems, e-learning environments.

Designing interactive systems that could be effectively, efficiently and with satisfaction used by people exhibiting different characteristics, needs, preferences and abilities is getting more and more important in Information Technology research and development, as it is clearly demonstrated by the growing importance of the user role in research projects as well as in public administration developments, by the introduction in several Laws of precise usability and accessibility requirements for governmental information systems, by the continuous increase of funding for HCI-related research at EU and international level.

We have been among the pioneers of the research in this field in Europe, in particular in the effort of giving formal basis to the definition of interaction while considering human-related, perceptual aspects. We are still continuing in this direction, in particular by working on a machine-interpretable and machine-learnable model of user task that will be the basis for a novel task-oriented interaction model, to be tested in personal information environments. Furthermore, innovative interaction styles, e.g. brain-computer interfaces, ubiquitous and sensor-based environments, extreme visualizations, are under study, as well as novel design methodologies, advancing traditional user-centered design both with the injection of agile concepts and directly encompassing accessibility aspects.

### Projects:

- *Collaboration and Decision Making in Engineering* - October 2010, September 2014 - EU FP7
- *PROMISE – PARTECIPATIVE Research Laboratory for Multimedia and Multilingual Information Systems Evaluation* - September 2010, August 2010 - EU FP7
- *BrIndiSys – Brain-computer interface devices to support individual autonomy in locked-in individuals* - October 2010, September 2013 - AriSLA Bando 2009
- *understandIT* - October 2010, September 2012 - Leonardo Da Vinci programme
- *SM4All - Smart homes for all* - September 2008, August 2011 - EU FP7.
- *WORKPAD - An Adaptive Peer-to-Peer Software Infrastructure for Supporting Collaborative Work of Human Operators in Emergency/Disaster Scenarios* - September 2006, August 2009 - EU FP6.
- *DELOS - Network of Excellence on Digital Libraries* - January 2004, December 2008 - EU FP6.
- *VisMaster - Coordination Action on Visual Analytics* - August 2008, July 2010 - EU FP7.

- *QUIS - QQuality, Interoperability and Standards in e-learning* - February 2005, April 2007 - EU FP6.

### Journals

- [1] Gabrielli S. and Catarci T. Welcome message from the editors-in-chief. *ICST Transactions on Ambient Systems*, 11(10-12), 2011.

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- [2] Di Ciccio C., Mecella M., and Catarci T. Representing and visualizing mined artful processes in MailOfMine. In *Information Quality in e-Health - Proceedings of the 7th Conference of the Workgroup Human-Computer Interaction and Usability Engineering of the Austrian Computer Society*, pages 83–94, 2011.
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## 3.11 Industrial Organization and Management

### Research lines:

- Competition, Regulation and Industrial Policy
- Economics of Network Industries
- Efficiency Analysis
- Industry Studies: Telecommunications, Transportation, Utilities, and Services
- Management Control Systems
- Mechanism Design and Auctions
- Operations Management

**Members:** Alessandro Avenali, Giuseppe Catalano, Rosa Maria Dangelico, Cinzia Daraio, Domenico Laise, Claudio Leporelli (leader), Giorgio Matteucci, Alberto Nastasi, Fabio Nonino, Pierfrancesco Reverberi.

**Post Docs:** Anna D'Annunzio.

**PhD Students:** Tiziana D'Alfonso.

Our research field includes general issues in industrial economics and management, with an emphasis on competition, regulation and investment in network industries. In particular, our research activity is at present focused on the following topics:

*Regulation and competition in the telecommunication industry* - We study the impact of access regulation on investment in a dynamic framework where developing an infrastructure requires both time and a captive customer base. We define dynamic models to assess whether and when the *ladder of investment* regulatory paradigm induces efficient competitive network investment. In this framework we analyze the credibility and dynamic consistency of multiperiod regulated access price schedules. We also analyze the impact of the industry structure (vertical integration or separation) on investment incentives and we assess if vertical separation of the telecommunications incumbent may be an effective and proportionate remedy when the access network is an enduring economic bottleneck.

*Regulation and competition in the air transport industry* - We study the incentives for airports and carriers to vertical cooperation and the effects of competitive pressures in both the airlines and airports markets over these incentives. Specifically, our findings provide theoretical and policy concerns with respect to the analysis of different contracts between airports and their respective dominant airlines and their effects in terms of social welfare, pro or anti competitiveness and the ensuing regulatory requirements.

*Bundling* - We show how a monopolist in a primary market uses mixed bundling to extract surplus from quality-enhancing investment by a single-product rival in a complementary market, or even force the rival to provide low quality. Although we assume that bundling creates efficiency gains, we find that bundling reduces consumer surplus and may reduce social welfare, even if the rival is not foreclosed, and investment is not blocked. Nonetheless, bundling improves welfare when prevents inefficient investment. We propose to check bundled offers via a price test that controls the monopoly component stand-alone price to preserve efficiencies from both bundling and investment. When the rival invests, the test improves consumer surplus and welfare compared with the do-nothing scenario, or a ban on bundling.

*E-procurement* - We innovate procurement design related to outsourcing of facility management activities by developing a multi-attribute combinatorial auction-based mechanism which allows a procurer and sellers to dynamically and simultaneously bargain the characteristics of distinct procurement contracts. The proposed mechanism allows the procurer to mitigate the relevant problem concerning the lack of competences on the non-core activities, since it can partially extract from sellers their private information regarding both economic and technical issues.

*Supply chain management* - We carried out an exploratory case study in order to widen the knowledge basis on supply chain learning by exploring and explaining how an enterprise can compete and win in the international market by integrating the quality management practices along its supply chain and, above all, by becoming the coordinator in a

supply chain learning (SCL) network. We found that the diffusion of a culture of quality sustains the supply chain learning towards the continuous improvement of product and service quality and, above all, can mitigate the companies effort by creating an emergent behavior in the different actors that self-aligns their activity to a shared culture.

*Social networks analysis* - We studied the key roles embedded in the informal organizational structure (informal networks) outlining their contribution in the case study of a knowledge-based enterprise operating in the information systems industry. Furthermore we find and characterize a new key informal role that synthesizes problem solving, expertise, and accessibility characteristics.

*Innovation management* - We reviewed the literature on motivations in collaboration and we analyzed 26 open innovation web-based platforms which allow the collaboration of individuals and companies and the so-called crowdsourcing identifying the effects of motivational systems and platforms models on the attraction of the knowledge providers in the different phases of innovation process.

*Knowledge strategy* - We reviewed the three main strategies in the literature of knowledge management: the knowledge development (internal or external), the knowledge sharing (codification or personalization strategy) and the knowledge exploitation (internal or external) in order to propose a model and a three step methodology for assessing the coherence of companies knowledge strategy to its business strategy and to its competitive and organizational context.

*Efficiency analysis* - We have worked on the improvement of the non parametric approach in efficiency analysis, introduction of robust methods and general approaches to explain inefficiency differentials.

*Multi-criteria managerial decision making* - Our research illustrates the advantages of the multi-criteria methodology applied to managerial decision making problems. This methodology is founded on the notion of outranking to the benchmarking analysis of organizational learning capability.

#### Projects:

- COLLECTIVE - *Emerging communities for collective innovation: ICT Operational tool and supporting methodologies for SME Associations* - January 2010, January 2013 - EU FP7.

#### Journals

- [1] De Toni A.F., Pivetta M. and Nonino F., A model for assessing the coherence of companies' knowledge strategy. *Knowledge Management Research & Practice*, vol. 9, n. 4:327-341, 2011.

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- [2] De Toni A. F., Biotto M., Nonino F., Sustaining quality from the green coffee to the cup: logistics as a competitive weapons *In: De Toni A.F. Ed., International Operations Management*, Gower, ISBN/ISSN: 978-1-4094-0329-6.



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### Theses

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- [10] Avenali A., Battistella C. Matteucci G., Nonino F., A mechanism for supporting collective innovation: the open contract-based challenge. *Information Systems and e-Business Management*, 2011, submitted.
- [11] Avenali A., D'Annunzio A., Reverberi P., Bundling, Competition and Quality Investment: a Welfare Analysis. *Review of Industrial Organization*, 2011, submitted.
- [12] Baldissin N., Greco M. and Nonino F., What is a Business Game? An in-Depth and Explanatory Taxonomy in the Business Niche of Game Based Learning. *Simulation and Gaming*, 2011, submitted.

- [13] Barbot M.C., D'Alfonso T., Malighetti P., Redondi R., Vertical collusion between airports and airlines: an empirical test for the European case. *Transportation Research: Part E*, 2011, submitted.
- [14] Battistella C., Nonino F., Exploring the impact of motivations on the attraction of innovation roles in open innovation web-based platforms. *Production Planning and Control*, forthcoming.
- [15] Battistella C., Nonino F., What Drives Collective Innovation? - Exploring the system of drivers for motivations in open innovation web-based platforms. *Information Research*, forthcoming.
- [16] Biotto M., De Toni A. F., Nonino F., Managing product quality along the supply chain without a vertical integration: the illycaffé case study. *International Journal of Logistics Management*, submitted.
- [17] D'Alfonso T., Changmin J., Wan Y., Passenger types and concession revenues: effects on airport pricing. *Working Paper, CTS Center for Transportation Studies, University of British Columbia*, 2011.
- [18] D'Alfonso T., Changmin J., Wan Y., Airport pricing, concession revenues and passenger types. *Journal of Transport Economics and Policy*, 2011, forthcoming.
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### **3.12 Modeling, Simulation, and Control in Biological and Biomedical Systems**

**Research lines:**

- Optimal Estimation and Control Problems
- Analysis and Modelling of Metabolic Systems
- Methods and Techniques for Neuroengineering
- Computational Optimization and Optimal Control in Medicine and Biology

**Members:** Carlo Bruni, Febo Cincotti, Lorenzo Farina, Serenella Salinari (leader).

**PhD Students:** Pietro Aricò, Francesca Schettini, Federico Papa, Jlenia Toppi.

**Post Docs:** Fabio Aloise, Laura Astolfi.

The research activity in this area concerns the development of general methodologies of modelling, estimation and optimal control theory, as well as their application in the study of biomedical and biological systems. Indeed, researches on biomedical applications were performed since the early 70's with regard to biomechanics, prostheses and modelling of cellular growth. At present, many groups in the Dpt. of Computers and System Sciences, are working in the above mentioned research lines at different levels of engagement. In this context, the main research topics are:

- Measurement policy in optimal filtering and control problems;
- Statistical modelling of retinal data for diagnostic purposes;
- Modelling and Identification of tumor spheroids response to radiations;
- Analysis and modelling of glucose and lipid metabolism and their interaction;
- Estimation of cerebral connectivity in humans by means of structural and functional models;
- Implementation of devices for Brain Computer Interface based on parameters of the estimated cortical activity or on the real-time analysis of video-sequences;
- Medical image analysis, in particular aimed to develop segmentation methods able to enhance the retrieved information from different kind of images (mammographic data, pupil and liver tissue images etc.);
- Computational optimization in applicative topics of systems biology.

The future activity of the group will mainly focus on the research on the optimal measurement times in the filtering problems; the study of the mechanisms on the basis of insulin secretion and on the insulin resistance; the investigation about the possible application of the Brain computer Interface techniques in the rehabilitation; the utilization of the neuroengineering tools in the field of the economy/marketing; the optimization of tumor radiotherapy; the statistical procedures for automatic diagnosis of retinal pathologies; the computational methods for the analysis of genome wide expression data and the topological features and criticalities in metabolic networks.

Many national and international cooperations are actually active as: Dip. di Fisiologia Umana e Farmacologia dell'Università di Roma "Sapienza (Roma), Istituto di Medicina Interna Università Cattolica - Policlinico A. Gemelli (Roma), Istituto di Biologia e Patologia Molecolari - CNR (Roma), Istituto di Analisi dei Sistemi e Informatica (IASI) – CNR (Roma), Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione INRAN (Roma), Istituto Superiore di Sanità (Roma), Department of Biomedical Engineering - Boston University (USA), Dpt. of Biomedica and Electrical Engineering - University of South California (USA), ECE Kansas State University (USA), Institut del la Santé et de la Recherche Medicale-Unité 870 Faculté de Medicine Lyon.

## Journals

- [1] Aloise F., Schettini F., Aricò P., Leotta F., Salinari S., Mattia D., Babiloni F. and Cincotti F., P300-based brain-computer interface for environmental control: an asynchronous approach. *Journal of Neural Engineering*, 8(2):025025, 2011.
- [2] Aloise F., Schettini F., Aricò P., Salinari S., Guger C., Rinsma J., Aiello M., Mattia D. and Cincotti F., Asynchronous P300-based brain-computer interface to control a virtual environment: initial tests on end users. *Journal of Clinical EEG Neuroscience*, 42(4):219-24, 2011.
- [3] Astolfi L., Toppi J., De Vico Fallani F., Vecchiato G., Cincotti F., Wilke C.T., Yuan H., Mattia D., Salinari S., He B. and Babiloni F., Imaging the Social Brain by Simultaneous Hyperscanning During Subject Interaction. *IEEE Intelligent Systems*, 26(5):38-45, 2011
- [4] Babiloni F., Cichocki A., Sanei S., Astolfi L., Cincotti F. and Gonzalez Andino S., Selected papers from the 4th International Conference on Bioinspired Systems and Cognitive Signal Processing. *Computational Intelligence and Neuroscience*, 2011:913040, 2011.
- [5] Bruni C., Koch G. and Papa F., A measurement policy in stochastic linear filtering problems. *Computer and Mathematics with Applications*, 61(3):546-66, 2011.
- [6] De Vico Fallani F., Rodrigues F.A., da Fontoura Costa L., Astolfi L., Cincotti F., Mattia D., Salinari S. and Babiloni F., Multiple pathways analysis of brain functional networks from EEG signals: an application to real data. *Brain Topography*, 23(4):344-54, 2011.

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- [8] Kleih S.C., Kaufmann T., Zickler C., Halder S., Leotta F., Cincotti F., Aloise F., Riccio A., Herbert C., Mattia D. and Kübler A., Out of the frying pan into the fire—the P300-based BCI faces real-world challenges. *Progress in Brain Research*, 194:27-46, Review, 2011.
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- [13] Vecchiato G., Astolfi L., De Vico Fallani F., Toppi J., Aloise F., Bez F., Wei D., Kong W., Dai J., Cincotti F., Mattia D. and Babiloni F., On the use of EEG or MEG brain imaging tools in neuromarketing research. *Computational Intelligence and Neuroscience*, 2011:643489, 2011.
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- [15] Vecchiato G., Toppi J., Astolfi L., De Vico Fallani F., Cincotti F., Mattia D., Bez F. and Babiloni F., Spectral EEG frontal asymmetries correlate with the experienced pleasantness of TV commercial advertisements. *Medical and Biological Engineering and Computing*, 49(5):579-83, 2011.

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- [17] Bruni C., Koch G. and Papa F., Measurement saving versus estimate accuracy in linear filtering problems *IFAC World Congress, Milan 28/8-2/9 2011*
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- [19] Astolfi L., Toppi J., Borghini G., Vecchiato G., Isabella R., De Vico Fallani F., Cincotti F., Salinari S., Mattia D., He B., Caltagirone C. and Babiloni F., Study of the functional hyperconnectivity between couples of pilots during flight simulation: an EEG hyperscanning study. *Conf. Proc. IEEE Engineering in Medicine and Biology Society*, 2338-41, 2011
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- [22] Aiello M., Aloise F., Baldoni R., Cincotti F., Guger C., Lazovik A., Mecella M., Pucci P., Rinsma J., Santucci G. and Taglieri M., Smart homes to improve the quality of life for all. *Conf. Proc. IEEE Engineering in Medicine and Biology Society*, 1777-80, 2011.
- [23] Astolfi L., Toppi J., Cincotti F., Mattia D., Salinari S., De Vico Fallani F., Wilke C., Yuan H., He B. and Babiloni F., Methods for the EEG hyperscanning. Simultaneous recordings from multiple subjects during social interaction *8th International Symposium on Noninvasive Functional Source Imaging of the Brain and Heart and 8th International Conference on Bioelectromagnetism*, Article number 5936807, pp. 5-8, 2011.
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#### Theses

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- [30] Bertuzzi A., Gniuli D., Gui D., Leccesi L., Mingrone G., Rubino F., Runfola M. and Salinari S., Jejunal bypass and jejunectomy improve insulin sensitivity in spontaneous diabetic rats. Submitted.
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- [32] Bruni C., Koch G. and Papa F., Estimate accuracy versus measurement cost saving in continuous time linear filtering problems. Submitted.
- [33] Papa F. and Sinisgalli C, Optimal solution for a cancer radiotherapy problem with a maximal damage constraint on normal tissue. Tech. Rep. DIAG 2011, n 7.

### 3.13 Multi-Agent and Multi-Robot Systems

#### Research lines:

- Cooperation and Coordination
- Distributed Planning and Problem Solving
- Information Fusion and Situation Assessment
- Cognitive Human-Robot Interaction
- Multi-Agent/Robot Learning
- Cooperative Perception

**Members:** Giorgio Grisetti, Luca Iocchi, Daniele Nardi (leader), Giuseppe Oriolo, Marilena Vendittelli.

**PhD Students:** Ricardo Dodds, Andrea Pennisi, Erfan Shojaei Barjuei, Thien Nguyen-Duc, Gabriele Randelli, Paolo Stegagno.

**PhD Students** (from other Universities): Keith Sullivan (George Mason Univ., Fairfax, VA, USA), Erdi Aker (Sabanci Univ., Istanbul Turkey)

**Post Docs:** Domenico Bloisi, Daniele Calisi, Matteo Leonetti, Luca Marchetti.

The research in this area stemmed from the work on Cognitive Robotics and Artificial Intelligence, and the specific focus on multi-agent and multi-robot system has been originated by the participation in RoboCup competitions, starting back in 1998. The RoboCup competitions provide a very challenging experimental framework both for multi-robot systems and for (virtual) multi-agent systems. Consequently, the research developed in the area of Multi-Agent and Multi-Robot Systems has produced both theoretical results on several research problems as well as a number of prototype implementations.

The research topics addressed include:

- Cooperation and Coordination
- Distributed Planning and Problem Solving
- Information Fusion and Situation Assessment
- Cognitive Human-Robot Interaction
- Multi-Agent/Robot Learning
- Cooperative Perception

The implementation effort has been supported through OpenRDK, a software framework for the development of robotic applications, that has been released to the community (<http://openrdk.sourceforge.net>). The application domains, where the research ideas have been tested and experimentally evaluated, include virtual agents in search and rescue simulation and multi-robot systems in soccer, search and rescue, surveillance and domotics.

The growing complexity of applications makes a distributed approach, where several agents can work in cooperation, more and more compelling. Moreover, the interaction between agents and humans will play an increasing role, to support the deployment of teams of robotic agents (including sensor networks) as well as of new software solutions that are conceived as multi-agent systems. Consequently, the work in this area is expected to grow by addressing new research challenges and by exploiting the potential of the new robotic platforms available, ranging from NAO humanoid robots by Aldebaran, to mini UAVs deployable in search and rescue operations, to more traditional wheeled platforms.



The group has a solid tradition of cooperation with other research groups worldwide, and is very interested in establishing new collaborations and hosting foreign researchers.

### Projects:

- *BEESAFE* - December 2011, April 2013 - Sistemi Software Integrati - Daniele Nardi.
- *SAMAS: Sistema adattativo multi robot e sue applicazioni per lo sminamento - Servizi di cooperazione* (Adaptive multi-robot services and its applications to demining - Cooperation services) - April 2010, July 2011 - Space Software Italia - Daniele Nardi.
- *Smart Monitoring of Complex Public Scenes* - May 2011, April 2013 - Dept. of Homeland Security (DHS), USA - Daniele Nardi, Luca Iocchi.
- *Sistema pubblicità virtuale 3D (VIVA)* - January 2011, July 2012 - Duel TV - Daniele Nardi, Luca Iocchi.
- *Situation Awareness, Iniziativa Software 2* - April 2010, March 2012 - SESM, SELEX-SI, Finmeccanica - Daniele Nardi.
- *CAMP: Context-Aware Mobility Platform* - Jan 2009, Dec 2011 - Ministero dello Sviluppo Economico (Industria 2015) - Luca Iocchi.

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### 3.14 Networked Systems

**Research lines:**

- Control of Networks, Control over Networks
- Control under Communication Constraints
- Modeling, Filtering and Optimal Control of Communication Networks
- Remote Control

**Members:** Carlo Bruni, Francesco Delli Priscoli (leader), Claudio De Persis, Alessandro Di Giorgio, Antonio Pietrabissa.

**PhD Students:** Andrea Fiaschetti, Laura Fogliati, Guido Oddi, Andi Palo, Martina Panfili, Laura Pimpinella, Filippo Rodriguez, Marco Veroli.

**Post Docs:** Marco Castrucci, Andrea Mercurio, Silvano Mignanti, Vincenzo Suraci.

The networked systems area has developed, in the last 12 years, thanks to the successful participation in 34 major advanced research projects mainly financed by the European Union (EU), carried on together with major European ICT players. The networked systems area supports a Future Internet vision (in particular, the group participates to the large FI-WARE EU project just concerning the Future Internet technology foundation) foreseeing a technology independent distributed framework including coordinated advanced control algorithms (utilizing methodologies such as reinforcement learning for multi-agent systems, data mining, game theory, bounded optimal control, predictive control and robust control). These algorithms, on the basis of homogeneous integrated metadata (deriving from properly selected heterogeneous information related to the present network and user status, converted in metadata and aggregated in a context-aware fashion), take consistent decisions (which are eventually actuated in the networks) concerning the management of network resources and of network contents/services, aiming at maximizing resource exploitation, while satisfying users in terms of Quality of Experience expectations (related to Quality of Service, security, mobility, ... requirements). For dealing with the above-mentioned vision, the networked systems area deals with the following key enablers: model-free learning, multi-agents with minimum coordination, cross-layering/cross-network optimization, context awareness, data fusion, decision support systems. In the framework of the in progress projects, the above-mentioned vision has been applied in the following areas: home network speed enhancement up to Gbps, optimization of hybrid ad hoc and satellite networks, resource management for telecommunication and energy distribution networks (smart grids), demand side management for planning electric utilities, smart grids for supporting fully electrical vehicles, content management for peer-to-peer television, protection of critical infrastructures, total airport security, embedded system security/privacy/dependability, remote diagnosis

and management of cardiovascular diseases, space assets for demining assistance, wireless cognitive sensor networks.

### Projects:

- *BRAVEHEALTH, Patient Centric Approach for an Integrated Adaptive, Context Aware Remote Diagnosis and Management of Cardiovascular Diseases* (managed by CRAT) - March 2010, February 2014 - EU ICT FP7 Project.
- *DLC+VT4IP, Distribution Line Carrier: Verification, Integration and Test of PLC Technologies and IP Communication for Utilities* (managed by CRAT) - January 2010, December 2012 - EU ICT FP7 Project.
- *Fi-WARE, Future Internet Core Platform* - May 2011, April 2014 - EU ICT FP7 Project
- *MICIE, Tool for Systemic Risk Analysis and Secure Mediation of Data Exchanged across Linked CI Information Infrastructures* (managed by CRAT) - September 2008, February 2011 - EU ICT FP7 Project.
- *MONET, Mechanisms for Optimization of Hybrid Ad-hoc and Satellite Networks* (managed by CRAT) - January 2010, June 2012 - EU ICT FP7 Project.
- *nSHIELD, New embedded System architecture for multi-Layer Dependable solutions* - September 2011, August 2014 - EU ARTEMIS-JU Project
- *OMEGA, Home Gigabit Access* (managed by CRAT) - January 2008, March 2011 - EU ICT FP7 Project.
- *P2P-Next, Next Generation Peer-to-Peer Content Delivery Platform* - January 2008, December 2011 - EU ICT FP7 Project.
- *P3C, Plug and Play Process Control Project* (managed by Aalborg University) - September 2006, August 2011 - Danish Research Council for Technology and Production Sciences.
- *pSHIELD, Pilot embedded System architecture for multi-Layer Dependable solutions* - June 2010, May 2011 - EU ARTEMIS-JU Project
- *SAFEDEM, Space Assets For Enhanced DEMining Assistance* - January 2011, March 2012 - ESA AO/1-6392/10/NL/CLP Project
- *SMARTV2G, Smart Vehicle to Grid Interface* - June 2011, May 2014 - EU FP7-2011-ICT-GC Project
- *TASS, Total Airport Security System* - April 2010, March 2014 - EU FP7-2011-ICT-GC Project

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- [13] Di Giorgio A., Liberati F., Interdependency Modeling and Analysis of Critical Infrastructures Based on Dynamic Bayesian Networks. *Proceedings of the 19th Mediterranean Conference on Control and Automation MED11*, 791-797, Corfu, GR, June 2011.
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- [16] Fiaschetti A., Losquadro G., Petrone M., Tomasicchio G., A resource management architecture for multimedia satellite systems with mesh connectivity. *Proc. of the 17th Ku/Ka Band Conference (KACONF-11)*, Palermo, IT, 2011.
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### 3.15 Nonlinear Systems and Control

#### Research lines:

- Robust Control
- Stability and Stabilization
- Tracking and Regulation
- Optimal Control and Stochastic Systems
- Hybrid Systems
- Discrete-time and Sampled Data Systems
- Data Acquisition and Sensor Networks
- Control Applications

**Members:** Stefano Battilotti, Luca Benvenuti, Claudia Califano, Claudio De Persis, Paolo Di Giamberardino, Daniela Iacoviello, Alberto Isidori (leader), Salvatore Monaco.

**PhD Students:** Andrea Abelli, Giovanni Mattei, Silvia Paris, Daniele Pucci.

Research on nonlinear systems and control at the University Sapienza has been active since the early 70s and, historically, has played a major role worldwide. The geometric approach to nonlinear feedback design, developed in the late 70s, marked the beginning of a new area of research which, in the subsequent decades, has profoundly influenced the development of the entire field. The concept of (nonlinear) feedback equivalence and of zero dynamics, their properties and implications in feedback design, are perhaps the most frequently used concepts in feedback stabilization. The geometric approach also plays a fundamental role in the analysis of systems evolving on Lie groups, with numerous applications to the control of spacecrafts and mobile robots. The natural evolution of the geometric approach to analysis and design of nonlinear systems led to a refinement of concepts underlying the design of nonlinear controllers to the purpose of shaping the



steady-state behavior of a system. Currently, this line of research is pursued with the study of problems arising in the regulation of systems possessing unstable zero dynamics and in the development of methods for robust stabilization via measurement feedback. A general framework for robust stabilization reposes of the concept of filtered Lyapunov functions. Tools for the design of composite filtered Lyapunov functions have been developed. Robust and nonlinear control techniques have proven useful to achieve control objectives in the case of restricted information structure, e.g. measurements taking values only in a finite set and/or feedback delivered to the actuators erratically. A major challenge in the research on control with limited information is the design of controllers which are distributed over a network. In this case, the controllers cooperate to achieve a common goal but have access only to limited information provided by their neighbors.

Analysis and design of real control systems integrating devices and computational procedures in a digital context involves ad-hoc methods. Nonlinear discrete-time and sampled data systems are the subjects of an investigation developed at La Sapienza from the early 80s, in a still active cooperation with the Laboratoire des Signaux et Systèmes of the French CNRS. The research activity has been focused on solving nonlinear control problems in discrete-time and on finding digital solutions to continuous-time control systems. One of the major outcome of the investigation has been the settlement of an original approach, mixed by algebraic and geometric concepts, used either to prove the existence of solutions in discrete-time or to compute approximated solutions in the digital context. Two aspects are at the bases of the more recent developments: a new representation of discrete-time dynamics, which provides a natural framework for comparing results from the continuous-time and discrete-time contexts, the concept of exact sampled model under feedback, which can be used to design piecewise continuous controllers in a direct digital context. From the solution to feedback linearization, stabilization, regulation, observer theory, new research lines are in the direction of Lyapunov and passivity based design, inverse optimal control and time delayed systems in discrete-time and under sampling. Particular attention is devoted to the settlement of executable algorithms for computing the proposed solutions.

Measurements devices, algorithms, data handling and transmission represent critical aspects in any distributed control problem. The number of devices, their location, the energy consumption, the data-communication links and the distributed data handling are nowadays classical problems in this context. New issues deal with dynamic sensor networks, where mobile platforms are assimilated to intelligent devices, in which motion planning and control problems pose additional requirements and make harder the solution of the task. The full problem formulation as a high dimensional nonlinear dynamics is a challenging interdisciplinary area of research towards easier and cheaper solutions to problems like surveillance, monitoring, decentralized and distributed control. Problems under investigation in this field concern sensor and actuator devices, computation algorithms, local and global coordinated control, network communication protocols and data acquisition and fusion.

The applicative aspects of the research activities are carried out at the System and Control Laboratory, founded in 1995.

**Projects:**

- *Stability analysis and implementation of networked systems governed by Kuramoto oscillators* (2 consecutive projects) - September 2008, August 2010 - The Johns Hopkins University Applied Physics Laboratory.
- *Totally polymeric ionic transducers: applicability study, performance analysis and prototypical realizations for advanced sensor-actuator devices* - March 2010, December 2012 - MIUR PRIN.
- *SARFIRE* February 2010 - February 2012 - ASI.
- *Microstructure influence on fatigue damaging micro-mechanisms in ductile cast irons* - 2011, MIUR PRIN 2009.

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- [42] Monaco S. and Normand-Cyrot D., Nonlinear optimal stabilizing control under sampling, to appear *Proc. American Control Conference*, Montreal, June 2012.
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### 3.16 R&D, Innovation, and Internationalization

#### Research lines:

- Internationalization, Innovation and Environment
- Coalition Formation Models and Collusive Agreements in Oligopolies
- The Governance of Nonprofit Organizations
- Public Debt, Distortionary Taxation and Monetary Policy

**Members:** Marco Antonio Marini, Maria Luisa Petit Tarascon, Giorgio Rodano, Francesca Sanna-Randaccio (leader), Roberta Sestini .

This group has recently investigated the theoretical explanations and empirical implications of some interrelated phenomena, namely, technological innovation, strategic behaviour of Multinational Enterprises (MNEs) in R&D intensive industries, environmental and foreign direct investment (FDI) policies, R&D agreements in oligopolies. These research topics combine two strands of research previously followed by members of the group. A first line of analysis concerned the study of R&D investment decisions, applying optimal control and dynamic game methods. The other line of enquiry dealt with different aspects of firms' choice of international strategy following a game-theoretic approach.

These streams of research have converged, producing in the more recent years a series of results concerning firms' innovative activities, their international expansion via foreign direct investment (FDI), the dynamic behaviour of firms' R&D agreements and the role of nonprofit organizations in oligopolistic markets.

Currently the following research topics are under investigation by group's members:

*R&D and Asymmetries in Knowledge Transmission* - Moving from the above sketched line of analysis, we investigated how firms R&D investment decisions and welfare are affected by asymmetries in knowledge transmission (i.e. asymmetric spillovers), taking into account different sources of asymmetry, such as unequal know-how management capabilities and spillovers localization within an international oligopoly.

*Cross Border M&A* - Stemming from the observation that global FDI activities are dominated by cross border acquisitions, especially between industrialized countries, some research was carried out to identify under which conditions a technology leader from a small country acquires a laggard from a large country, and vice versa. We find that, to become the acquirer, a firm from a small country needs not only a strong technological lead but also the ability to exploit it on a global scale, which requires low international technology transfer costs. Moreover, it is shown that a multilateral liberalization of greenfield investments may actually increase the incentives for foreign acquisitions.

*Endogenous R&D Agreements over Time* - We introduce a new class of models of endogenous agreements between firms under imperfect competition in which also the timing of actions is made endogenous. The purpose is to bridge two usually separate streams of literature, the noncooperative formation of alliances (R&D agreements, mergers etc.) and the endogenous timing literature. This allows us to consider the formation of agreements over time, analysing its impact on firms' innovative performance.

*Internationalization, Competitiveness and the Environment* - In pursuing this line of research we deal with the effects of unilateral environmental policies on firms' decision to relocate production abroad and on their technology transfer activities. In other terms, this research stream addresses the phenomenon of the so-called "carbon leakage", which is a key policy issue both in the EU and the US. We have analyzed this issue first considering a monopoly market structure and then an international oligopoly. Further research currently carried in this area out incorporates the hypothesis of firms' heterogeneity due to different emission coefficients. We have also investigated the role played by MNEs in the international technology transfer (ITT) and the implications for the countries involved. An important mechanism for facilitating the international transfer of environmental friendly technologies to developing countries is the so called Clean Development Mechanism (CDM). We have studied the role of CDM in channeling foreign technology to China. Our econometric analysis confirms that project size and cost, project location, credit buyers and consultants characteristics, as well as technology diffusion are all relevant factors in determining the probability to have a foreign supplier of technology in the project.

*The Governance of Nonprofit Organizations* - We develop various modelling tools for the analysis of the behaviour of consumer co-operatives and nonprofit organizations. In particular, a research line investigates the stability of coordination between mission-driven nonprofit organizations competing for donations. Another research line deals with the effect of managerial delegation in consumer co-operatives.

*Coalitions, Majorities and the Stability of Industrial Agreements* - We analyze a number of coalition stability concepts for the analysis of alliances and agreements within strategic settings. We prove that when the blocking power is restricted to majority coalitions, the core is nonempty for all expectations on outside players' behaviour in all symmetric supermodular games.

*Public Debt, Distortionary Taxation and Monetary Policy* - The interaction between fiscal and monetary rules is one of the most controversial issues in policy design. We prove that in the realistic case in which lump-sum taxes are unavailable, it can become impossible to implement passive fiscal policies.

### Journals

- [1] Sanna-Randaccio F. and Sestini R. Foreign Direct Investment and Environmental Policy: Have Location Factors Been Neglected ? *Asia-Pacific Journal of Accounting Economics*, 18 (1), 45–60, 2011.

### Chapters in Books

- [2] Rodano G. Claudio Napoleoni. in *Dizionario enciclopedico degli italiani*. Istituto della Enciclopedia Italiana, Rome, Italy, 2011.

### Conference Proceedings

- [3] Marini M.A., Petit M.L. and Sestini R. Endogenous Timing and R&D Agreements in a Duopoly with Spillovers. In *Proceedings of the EARIE 2011 Annual Conference*. Stockholm, Sweden, September 1-3, 2011.
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- [5] Sanna-Randaccio F. and Marconi D. Global Corporations, CDM and Technology Transfer to China. In *Proceedings of the Workshop on Foreign Direct Investment and Climate Change: New Research Directions*. ICCG, Island of San Giorgio Maggiore, Venice, October 7-8, 2011.

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- [6] Petit M.L., Sanna-Randaccio F. and Sestini R. R&D and Foreign Direct Investment with Asymmetric Spillovers. To appear in *Economics of Innovation and New Technology*.
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- [8] Piergallini A. and Rodano G. Public Debt, Distortionary Taxation, and Monetary Policy. To appear in *Rivista Italiana degli Economisti*.
- [9] Grunfeld L. and Sanna-Randaccio F. Cross Border MA: Who Buys Whom when Market Size and Technology Levels Differ ? Submitted.
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- [11] Marini M.A., Petit M.L. and Sestini R. The strategic timing of R&D agreements. WP EMS (Working Papers Series in Economics, Mathematics and Statistics), n. 2011/04, Università di Urbino, and SSRN (Social Sciences Research Network Discussion Papers, 2011.



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### 3.17 Robotics

#### Research lines:

- Robot Modeling, Planning, and Control
- Vision-based Control
- Sensor-based Planning and Exploration
- Physical Human-Robot Interaction
- Mobile Robots and UAVs
- Humanoid Robots
- Networked Robots

**Members:** Alessandro De Luca (leader), Giorgio Grisetti, Luca Iocchi, Leonardo Lanari, Giuseppe Oriolo, Marilena Vendittelli.

**PhD Students:** Fabrizio Flacco, Antonio Paolillo, Pietro Peliti, Lorenzo Rosa, Paolo Stegagno.

**Post Docs:** Massimo Cefalo.

The Robotics group at DIAG, and the associated Robotics Laboratory, were established in the late 1980s with a commitment to develop innovative planning and control methods for industrial and service robots.

The main research topics are: nonlinear control of robots; iterative learning of repetitive motion; hybrid force/velocity control of manipulators interacting with the environment; optimization schemes in kinematically redundant robots; motion planning and control of wheeled mobile robots and other nonholonomic mechanical systems; stabilization of underactuated robots; robot actuator fault detection and isolation; safe control of physical human-robot interaction; control of manipulators with flexible elements; control of locomotion platforms for VR immersion; image-based visual servoing; sensor-based navigation and exploration in unknown environments; motion planning for high-dimensional systems; multi-robot coordination and mutual localization.

In addition to further development in the above mentioned areas, recent activities include control and visual servoing for unmanned aerial vehicles (UAV), control-based motion planning for mobile manipulators, motion planning and control of locomotion in humanoid robots, and sensory supervision of human-robot interaction. We also pursue

more application-driven research, such as the development of a large team of mobile robots for luggage transport in airports.

All research activities undergo experimental validation in our Robotics Laboratory, that currently provides two articulated manipulators (a 6R industrial robot by KUKA and a Pendubot by Quanser) and several mobile robots, including both wheeled (a MagellanPro by iRobot plus a team of five Kheperas III by K-Team) and legged (2 quadruped Sony AIBOs) platforms. A recent acquisition is a NAO humanoid robot by Aldebaran. Finally, two quadrotor UAVs by AscTec (a Hummingbird and a Pelican) are available. All these robots are equipped with sensing devices of various complexity, going from ultrasonic/laser range finders to cameras, Kinect depth sensors and stereo vision systems. In the past, we have also designed and built a two-link flexible manipulator (FlexArm) and a differentially-driven wheeled mobile robot (SuperMARIO).

### Projects:

- *SAPHARI, Safe and Autonomous Physical Human-Aware Robot Interaction* - November 2011–October 2015 - EU FP7 IP (coordinator).
- *I-MULE* - January 2012–December 2014 - Industria 2015: Nuove Tecnologie per il Made in Italy.
- *MEMONET, Multirobot Exploration supported by MOBILE ad-hoc NETWORKS* - March 2010–September 2012 - MIUR PRIN.
- *SICURA, Sicurezza per l'Interazione nel Contatto Robot-Ambiente* (Safe Physical Interaction between Robots and Humans) - September 2008–September 2010 - MIUR PRIN (coordinator).

### Journals

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- [2] Souman J., Robuffo Giordano P., Schwaiger M., Frissen I., Thümmel T., Ulbrich H., De Luca A., Bühlhoff H., and Ernst M., CyberWalk: Enabling unconstrained omnidirectional walking through virtual environments. *ACM Transactions on Applied Perception*, vol. 8(4), pp. 24:1-24:22, 2011.

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- [4] Flacco F. and De Luca A., Residual-based stiffness estimation in robots with flexible transmissions. *Proc. 2011 IEEE International Conference on Robotics and Automation*, Shanghai, CHN, pp. 5541–5547, 2011.

- [5] Flacco F. and De Luca A., Stiffness estimation and nonlinear control of robots with variable stiffness actuation. *Proc. 18th IFAC World Congress, Milano, ITA*, pp. 6872–6879, 2011.
- [6] Flacco F., Kröger T., De Luca A., and Khatib O., Collision avoidance in the depth space. *2011 RSS Workshop on RGB-D: Advance Reasoning with Depth Cameras*, Los Angeles, CA, USA, June 2011.
- [7] Kümmerle R., Grisetti G., Stachniss C., and Burgard W., Simultaneous parameter calibration, localization, and mapping for robust service robotics. *2011 IEEE Workshop on Advanced Robotics and its Social Impacts*, Half Moon Bay, CA, USA, October 2011.
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- [10] Randelli G., Iocchi L., and Nardi D., User-friendly security robots. *Proc. 2011 IEEE International Symposium on Safety, Security, and Rescue Robotics*, Kyoto, JPN, pp. 308–313, 2011.
- [11] Ruhnke M., Kümmerle R., Grisetti G., and Burgard W., Range sensor based model construction by sparse surface adjustment. *2011 IEEE Workshop on Advanced Robotics and its Social Impacts*, Half Moon Bay, CA, USA, October 2011.
- [12] Stegagno P., Cognetti M., Franchi A., and Oriolo G., Mutual localization using anonymous bearing measurements. *Proc. 2011 IEEE/RSJ International Conference on Intelligent Robots and Systems*, San Francisco, CA, USA, pp. 469–474, 2011.

### Theses

- [13] Flacco F., *Modeling and Control of Robots with Compliant Actuation*. PhD thesis, Sapienza Università di Roma, 2011.
- [14] Stegagno P., *Mutual Localization from Anonymous Measures in Multi-Robot Systems*. PhD thesis, Sapienza Università di Roma, 2011.

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- [15] Censi A., Franchi A., Marchionni A., and Oriolo G., Simultaneous calibration of odometry and sensor parameters for mobile robots. Submitted to *IEEE Transactions on Robotics*.
- [16] Cognetti M., Stegagno P., Franchi A., and Oriolo G., 3-D Mutual localization with anonymous bearing measurements. Accepted for presentation at *2012 IEEE International Conference on Robotics and Automation*, St. Paul, MN, USA, May 2012.

- [17] De Luca A. and Flacco F., Integrated control for pHRI: Collision avoidance, detection, reaction and collaboration. Submitted to *4th IEEE RAS/EMBS International Conference on Biomedical Robotics and Biomechatronics*, Roma, ITA, June 2012.
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- [20] Flacco F., Kröger T., De Luca A., and Khatib O., A depth space approach to human-robot collision avoidance. Accepted for presentation at *2012 IEEE International Conference on Robotics and Automation*, St. Paul, MN, USA, May 2012.
- [21] Flacco F., De Luca A., Sardellitti I., and Tsagarakis N., On-line estimation of variable stiffness in flexible robot joints. Submitted to *International Journal of Robotics Research*.
- [22] Oriolo G., Peliti P., Rosa L., and Vendittelli M., Vision-based loitering over a target for a fixed-wing UAV. Submitted to *10th International IFAC Symposium on Robot Control*, Dubrovnik, HRV, September 2011.

### 3.18 Web Algorithmics and Data Mining

#### Research lines:

- Web Search and Mining
- Graph and Text mining
- Large-scale Complex Networks
- On-line Social Networks
- Algorithmic Mechanism Design and Network Economics

**Members:** Luca Becchetti, Stefano Leonardi (leader).

**PhD Students:** Riccardo Colini Baldeschi, Ida Mele.

**Post Docs:** Aris Anagnostopoulos, Ilaria Bordino, Piotr Sankowski.

Our interest is in algorithmic methods for characterizing the structure of large-scale complex networks with application to Web structure mining and Web usage mining. We have focussed so far on developing algorithms for graph based feature extraction and detection of significant patterns that characterize social activities, trust relationships and content quality.

In cooperation with Yahoo! Research group in Barcelona, we developed, analyzed and tested effective, scalable and efficient techniques for the automatic detection of topological structures in the Web graph that are likely to be the result of spamming activity. This research has been expanded to provide efficient methods to estimate the distribution of small substructures that are typically related to specific forms of social interaction. We also developed algorithmic methods for the extraction of meaningful information from the massive data available in query logs, a task of critical importance for detecting semantic relations between users, queries and pages. The design and analysis of economic mechanisms in the realm of the Internet and the Web and the computational issues of implementing economic mechanisms, as for instance ad auctions for on-line advertising, is another major research direction of our group. In the last few years we have concentrated our efforts in the area of the design of efficient cost-sharing and utilitarian mechanisms for network design, single and multi-objective optimization problems.

The Web has evolved from an excellent medium for sharing information into a complex and attractive social environment for the delivery of content rich information, products and services. In this respect, mining social network data for enhancing and personalizing web search and retrieval is a major research direction. Development of algorithmic strategies and analytic tools for influence spreading, viral marketing and technology adoption is of crucial importance for many computer mediated collaboration and commercial activities. E-commerce applications also require the implementation of economic mechanisms that address new problems, such as computerized auctions for Web ads. Marketing on the Web also requires sophisticated algorithmic tools for mining the huge amount of user activity data collected from search engines and other applications, for the identification of important trends or to provide fundamental tools, such as recommendation services. Finally, Web size and the increasing importance of the above applications pose serious scalability issues that we are going to tackle, such as the development of sophisticated ads and query caching techniques.

#### **Projects:**

- *DELIS, Dynamically Evolving Large Scale Information Systems* - January 2004, February 2008 - EU FP6 FET.
- *WEB RAM - Web Retrieval and Mining* (Projects managed by the Computer Science Department) - January 2007, December 2008 - MIUR PRIN.
- *COGENT - COmputational and GamE-theoretic aspects of uncoordinated NeTworks* - October 2008, September 2012 - MIUR PRIN.

## Journals

- [1] Anagnostopoulos A., Broder A. Z., Gabrilovich E., Josifovski V. and Riedel L., Web-page summarization for just-in-time contextual advertising. *ACM Transactions on Intelligent Systems and Technology*, 3(1):14:1–14:32, 2011.
- [2] Anagnostopoulos A., Kumar R., Mahdian M. and Upfal E., Sorting and selection on dynamic data. *Theoretical Computer Science*, 412(24):2564–2576, 2011.

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- [3] Anagnostopoulos A., Becchetti L., Mele I., Leonardi S. and Sankowski P., Stochastic query covering. In *Proc. 4th ACM International Conference on Web Search and Data Mining (WSDM)*, pages 725–734. ACM Press, 2011.
- [4] Anagnostopoulos A., Brova G. and Terzi E., Peer and authority pressure in information-propagation models. In *Proc. 22nd European Conference on Machine Learning and 15th European Conference on Principles and Practice of Knowledge Discovery in Databases (ECML/PKDD)*, pages 76–91. Springer, 2011.
- [5] Fiat A., Leonardi S., Saia J. and Sankowski P., Single-valued Combinatorial Auctions with Budgets. In *Proc. 12th ACM Conference on Electronic Commerce (EC)*, pp 223-232, 2011.

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- [6] Anagnostopoulos A., Becchetti L., Castillo C., Gionis A. and Leonardi S., Online team formation in social networks. To appear in *Proc. of the 21st International World Wide Web Conference (WWW)*. ACM Press, 2012.
- [7] Anagnostopoulos A., Kumar R., Mahdian M., Upfal E. and Vandin F., Algorithms on evolving graphs. In *Proc. 3rd ACM International Conference on Innovations on Theoretical Computer Science (ITCS)*, pages 149–160. ACM Press, 2012.
- [8] Becchetti L., Filipponi L. and Vitaletti A., Privacy support in people-centric sensing. Accepted for publication in *Journal of Communications*, Academic Publisher, 2012.
- [9] Colini-Baldeschi R., Henzinger M., Leonardi S. and Starnberger M., On Multiple Round Sponsored Search Auctions with Budgets. CoRR, <http://arxiv.org/abs/1112.6361>.
- [10] Feldman M., Fiat A., Leonardi S. and Sankowski P., Revenue Maximizing Envy-free Multi-unit Auctions with Budgets. To appear in *13th ACM Conference on Electronic Commerce (EC)*, Valencia, June 2012.
- [11] Leonardi S. and Roughgarden T., Prior-Free Auctions with Ordered Bidders. To appear in *Proc. of the 44th ACM Symposium on Theory of Computing (STOC)*, New York, May 2012.