

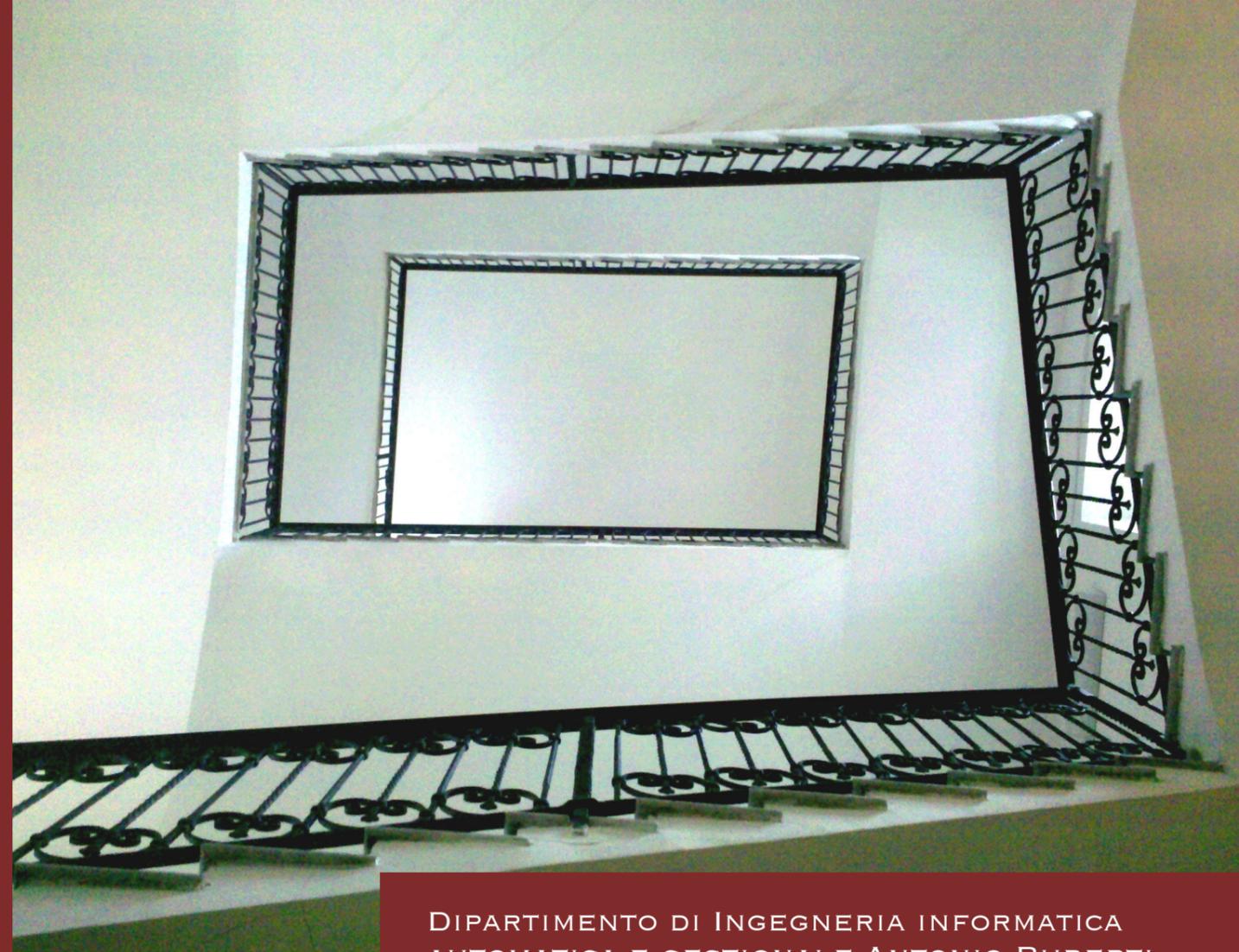
## DIAG - Research areas

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

Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti  
Via Ariosto 25, 00185 Roma  
[www.dis.uniroma1.it](http://www.dis.uniroma1.it)

Research Report 2013

Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti



DIPARTIMENTO DI INGEGNERIA INFORMATICA  
AUTOMATICA E GESTIONALE ANTONIO RUBERTI

## Research Report 2013



SAPIENZA  
UNIVERSITÀ DI ROMA

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

**Research report 2013**

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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 2013.

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 2013 consists of 27 full professors, 23 associate professors, and 29 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.diag.uniroma1.it> under the entry "Teaching".

Furthermore, DIAG offers two PhD programs, and cooperates with a PhD program offered by another department. They are briefly described in Section 2.4 of this report.

Research activities at DIAG are organized in 18 research areas. This organization is reflected in the structure of Section 3, where the research areas are described with a short overview of their main research lines, together with the list of people involved, and the collection of publications appeared in 2013.

## 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.diag.uniroma1.it>.

### 2.2 Facilities

#### Library

The 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. Several 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.

#### Laboratories

Several research and educational laboratories pertain to DIAG. 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.diag.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.diag.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.diag.uniroma1.it/dasilab>

Head: Maurizio LENZERINI

Organization: Massimo MECELLA

*E-learning systems and applications laboratory (ELSA)*

Via Andrea Doria 5 (Latina)

In the laboratory, advanced e-learning strategies for robotics and control systems are addressed, developed, implemented and tested through the use of real devices (mobile and articulated robots) available by a web based connection.

Web: <http://infocli31.dislt.uniroma1.it/elsa>

Co-Heads: Paolo DI GIAMBERARDINO and Marco TEMPERINI

*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.diag.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.diag.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.diag.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.diag.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://www.diag.uniroma1.it/~syscon/>

Head: Paolo DI GIAMBERARDINO

*Web Algorithmics and Data Mining Laboratory (WADAM)*

Via Ariosto 25 - room A221

The laboratory is devoted to the design of algorithms for web and data-mining related problems.

Web: <http://wadam.dis.uniroma1.it>

Head: Aris ANAGNOSTOPOULOS

*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.diag.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.diag.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.diag.uniroma1.it/~labinggest>

Person in charge: Massimo ROMA

## 2.3 People

*Head of Department* Alberto MARCHETTI SPACCAMELA

*Administration Head* Giovanna BIANCO

### *Professors*

Giorgio AUSIELLO (emeritus)  
 Roberto BALDONI  
 Stefano BATTILOTTI  
 Luigia CARLUCCI AIELLO  
 Giuseppe CATALANO  
 Tiziana CATARCI  
 Bruno CICIANI  
 Giuseppe DE GIACOMO  
 Alessandro DE LUCA  
 Francesco DELLI PRISCOLI  
 Gianni DI PILLO (emeritus)  
 Francisco FACCHINEI  
 Claudio GORI GIORGI  
 Alberto ISIDORI (emeritus)  
 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*

Alessandro AVENALI  
 Luca BENVENUTI  
 Fabrizio D'AMORE  
 Cinzia DARAIO  
 Camil DEMETRESCU  
 Alberto DE SANTIS  
 Lorenzo FARINA  
 Luca IOCCHI  
 Domenico LAISE  
 Leonardo LANARI  
 Paolo LIBERATORE  
 Carlo MANNINO (on leave)

Marco Antonio MARINI  
 Giuseppe ORIOLO  
 Laura PALAGI  
 Francesco QUAGLIA  
 Pierfrancesco REVERBERI  
 Massimo ROMA  
 Riccardo ROSATI  
 Serenella SALINARI  
 Silvio SALZA  
 Giuseppe SANTUCCI  
 Marco TEMPERINI

### *Assistant professors (ricercatori)*

Aris ANAGNOSTOPOULOS  
 Laura ASTOLFI  
 Luca BECCHETTI  
 Roberto BERALDI  
 Domenico Daniele BLOISI  
 Silvia BONOMI  
 Renato BRUNI  
 Claudia CALIFANO  
 Febo CINCOTTI  
 Rosa Maria DANGELICO  
 Claudio DE PERSIS (on leave)  
 Paolo DI GIAMBERARDINO  
 Alessandro DI GIORGIO  
 Marco FRATARCANGELI  
 Giorgio GRISSETTI  
 Daniela IACOVIELLO  
 Domenico LEMBO  
 Giorgio MATTEUCCI  
 Massimo MECELLA  
 Carlo Maria MEDAGLIA  
 Fabio NONINO  
 Fabio PATRIZI  
 Antonio PIETRABISSA  
 Alberto PRETTO (from September 2013)  
 Leonardo QUERZONI  
 Roberta SESTINI  
 Stravros VASSOS  
 Marilena VENDITTELLI  
 Andrea VITALETTI

*Post Doc research associates (assegnisti di ricerca)*

Gianluca AMORI  
Marek ADAMCZYK  
Maria Cristina ARCURI  
Emanuele BASTIANELLI  
Bruno CAFARO  
Camillo CARLINI  
Mario CARUSO  
Massimo CEFALO  
Ugo COLESANTI  
Chiara CONTI  
Fabrizio COSSU  
Tiziana D'ALFONSO  
Riccardo DE MASELLIS  
Maurilio DI CICCIO  
Diodato FERRAIOLI  
Fabrizio FLACCO  
Vincenzo FORTE  
Mario GIANNI  
Ettore IACOMUSSI  
Lukasz JEZ  
Lorenzo LAMPARIELLO  
Vittorio LATORRE  
Lorenzo LEPORE  
Mariano LEVA  
Riccardo MANCINI  
Silvano MIGNANTI  
Luca MONTANARI  
Guido ODDI  
Andrea PENNISI  
Giulia PERUZZI  
Fabio PREVITALI  
Gabriele RANDELLI  
Lorenzo ROSA  
Alessandro RUSSO  
Marco RUZZI  
Simone SAGRATELLA  
Alessandro SAULLO  
Fabio SAVO  
Arnab SINHA  
Paolo STEGAGNO  
Ylenia TOPPI

*Research assistants*

Silvia CANALE  
Cristina CIVILI  
Marco CONSOLE

Andrea FIASCHETTI  
Zoe FRAGOULOPOULOU  
Andrea LANNA  
Silvano MIGNANTI  
Giovanni MURRO  
Rossana NICOLÒ  
Valerio ORTENZI  
Andi PALO  
Martina PANFILI  
Marco Enrico PIRAS  
Sara PIZZIMENTI  
Valerio SANTARELLI  
Matteo SEMINAROTI  
Livia SOFFI  
Vincenzo SURACI  
Letterio ZUCCARO

*Administration staff*

Amelia ARRICALE  
Giovanna BIANCO  
Flavia CAGNIZI  
Antonietta CANGELLI  
Ugo CINELLI  
Giuditta FILOMENA  
Sabrina GIAMPAOLETTI  
Tiziana VALENTINI  
Maria Pia VANDILLI

*Technical staff*

Franco AMENDOLA (up to March 2013)  
Anna Paola DI RISIO (up to November 2013)  
Andrea DORI  
Giuseppe FILACI (up to January 2013)  
Marcello FIORINI (up to March 2013)  
Marco GIULIANI (up to April 2013)  
Luciano GRANDI  
Marcello PANI  
Tiziana TONI

*Auxiliary services*

Antonio SIMEONI

*Library*

Laura ARMIERO (up to February 2013)  
Roberta PROIETTI SEMPRONI  
Antonietta ZUCCONI (from May 2013)

## 2.4 Doctoral Programs

DIAG directly hosts the PhD programs in *Engineering in Computer Science* and in *Automatica and Operations Research*. Moreover, DIAG cooperates in the PhD programs in *Bioengineering*, hosted by the Department of Electric, Computer and System Sciences of the University of Bologna.

### 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>XXVI course</u>	<u>XXVIII course</u>	<u>XXIX course</u>
Pietro ARICÒ Francesca SCHETTINI	Elena PREVITI	Gianluca BORGHINI Manuela PETTI

*PhD theses completed in 2013*

Jlenia TOPPI

*Methods for the estimation of the cortical activity and connectivity during cognitive tasks in humans*

Advisor: Serenella SALINARI

### Engineering in Computer Science

The council of professors of the PhD program in Engineering in Computer Science 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*

XXV course	XXVI course	XXVII course
Ricardo DODDS	Leonardo ANIELLO	Giuseppe Antonio DI LUNA
Mario GIANNI	Francesco LEOTTA	Bruno CAFARO
Ida MELE	Khalil M.H. AL MASSRI	Mario CARUSO
	Alessandro PELLEGRINI	Cristina CIVILI
	Sebastiano PELUSO	Riccardo COLINI BALDESCHI
	Diego RUGHETTI	Nguyen DUC THIEN
	Alessandro RUSSO	Francesco FICAROLA
	Suzanne VAN DER STER	Andrea PENNISI
		Valerio SANTARELLI
XXVIII course	XXIX course	
Nadine ABU RUMMAN	Maurilio DI CICCO	
Marek ADAMCZYK	Mohammad ABU SNOBER	
Noor ALDEEN KAMEL	Davide AVERSA	
Marco ANGELINI	Roberto CAPOBIANCO	
Reem ATASSI	Claudio CICCOTELLI	
Taigo Maria BONANNI	Antonella DEL POZZO	
Daniele CONO D'ELIA	Martina DETURRES	
Marco CONSOLE	Federico FERRI	
Angela DI IORIO	Matteo MENNA	
Adriano FAZZONE	Mario PAOLI	
Giulia FISCON	Jacopo SERAFIN	
Guglielmo GEMIGNANI	Mara SORELLA	
Lorenzo LEPORE	Annalisa TERRACINA	
Maryam MOUSAVI IRAEI	Mohammad Salah UDDIN	
Valsamis NTOUSKOS	Alessio VAUDI	
Fabio PETRONI		
Fabio PREVITALI		

*PhD theses completed in 2013*

Lorenzo BERGAMINI

*Opportunistic computing in fully decentralized and mobile networks*

Advisor: Luca BECCHETTI

Domenico Fabio SAVO

*Dealing with Inconsistencies and Updates in Description Logic Knowledge Bases*

Advisor: Maurizio LENZERINI

Adriano CEROCCHI

*Valid Query Answers exploiting Node Virtualization*

Advisor: Leonardo QUERZONI

Riccardo DE MASELLIS  
*Verification of Artifact-centric Processes*  
Advisor: Giuseppe DE GIACOMO

Claudio DI CICCIO  
*On the Mining of Artful Processes*  
Advisor: Tiziana CATARCI

Paolo FELLI  
*Agent Behavior Synthesis from Components*  
Advisor: Giuseppe DE GIACOMO

Donatella FIRMANI  
*Large scale graph algorithms and applications*  
Advisor: Giorgio AUSIELLO

Andrea MARRELLA  
*SmartPM: Automatic Adaptation of Dynamic Processes at Run-Time*  
Advisor: Massimo MECELLA

Luca MONTANARI  
*Online Failure Prediction in Air Traffic Control Systems*  
Advisor: Roberto BALDONI

Hani QUSA  
*Enhancing Privacy Protection in Collaborative Data Aggregation Systems*  
Advisor: Roberto BERARDI

Roberto VITALI  
*Design of Software Support Structures for High Performance Optimistic Simulations with Special Focus on Multi-Core Hosting Environment*  
Advisor: Francesco QUAGLIA

### **Automatica and Operations Research**

The council of professors of the PhD program in Automatica and Operations Research is coordinated by Salvatore MONACO.

This PhD program was produced by merging the two former PhD programs in Systems Engineering and in Operations Research, and has two curricula: "Automatica" and "Operations Research". Students up to the XXVII course still belong to the former PhD programs. The research topics are: systems theory, automatic control, nonlinear systems, in-

telligent control, robotics, flexible manufacturing systems, biosystems, modelling, identification, optimal control, resource management for wireless systems, combinatorial optimization, nonlinear programming, network design, neural networks, logistics, management systems, and industrial systems economy.

*PhD students (working at DIAG)*

XXV course	XXVI course	XXVII course	XXVIII course
<i>Automatica</i> Pietro PELITI	<i>Automatica</i> Giorgia CHINI Andi PALO	<i>Automatica</i> Francesco LIBERATI Giovanni MATTEI	<i>Automatica</i> Raffaello BONGHI Federica CONTE
<i>Operations Research</i>	Martina PANFILI Silvia PARIS Lorenzo ROSA	Antonio PAOLILLO Letterio ZUCCARO	Marco COGNETTI Claudio Roberto GAZ Andrea LANNA
	<i>Operations Research</i> Alessandra REALE	<i>Operations Research</i> Andrea MANNO	Emanuele MAGRINI Marsilio TURATTI
			<i>Operations Research</i> Jahanbani ADEL Valentina BRACAGLIA Umberto DELLE PIANE Stefania RENZI
		<u>XXIX course</u>	
		<i>Automatica</i> Laura D'ORSI Dario Giuseppe FERRIERO Raffaele GAMBUTI Valerio MODUGNO	
		<i>Operations Research</i> Andrea CRISTOFARI Luca LABELLARTE	

*PhD theses completed in 2013*

*Operations research*

Gianpiero BIANCHI

*Optimization Techniques for Data Mining and Information Reconstruction*

Advisor: Renato BRUNI

Vittorio LATORRE

*Neural networks, surrogate models and black box algorithms: theory and applications*

Advisor: Gianni DI PILLO

Simone SAGRATELLA  
*Solution methods for quasi variational inequalities*  
Advisor: Francisco FACCHINEI

*Automatica*

Andrea ABELLI  
*Control Theory in Adaptive Optics: from the linear to the non linear case*  
Advisor: Salvatore MONACO

Andrea FIASCHETTI  
*Control Algorithms and Architectures for Resource Management in Multi-Layered Systems: Application to SATCOM, Security and Manufacturing Domains*  
Advisor: Francesco DELLI PRISCOLI

Guido ODDI  
*Reinforcement Learning and Cooperative Receding Horizon approaches for the routing problem*  
Advisor: Francesco DELLI PRISCOLI

Daniele PUCCI  
*Towards a unified approach to the control of aerial vehicles*  
Advisor: Salvatore MONACO

## 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 2013.

Leopoldo BERTOSSI, Carleton University, Ottawa, Canada, September- October 2013

Viktoriya DEGELER, University of Groningen, the Netherlands, September- November 2013

Paulo de Tarso GUERRA, University of São Paulo, Brazil, January-June 2013.

Omar S. HUJRAN, Princess Sumaya University for Technology, Jordan, August- September 2013

Seth HUTCHINSON, University of Illinois at Urbana, USA, September-December 2013

Sampath KANNAN, University of Pennsylvania, USA, February-May 2013

Stephen KIMANI, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya, March-May 2013

Yves LESPERANCE, York University, Toronto, Ontario Canada, May-November 2013

Jordan Janeiro LOPES DA SILVA, Delft University of Technology, the Netherlands, October-November 2013

Luciana SALETE BURIOL, Federal University of Rio Grande do Sul, Brazil, March 2013

Leopold SIMAR, Center for Operations Research and Econometrics (CORE), Université Catholique de Louvain, Belgium, March-May 2013

Mikhail SOUTCHANSKI, Ryerson University, Toronto, Ontario Canada, March-April 2013

Anming ZHANG, Sauder School of Business, University of British Columbia, Vancouver, Canada, June-July 2013

## **2.6 Seminars and Workshops**

Many scientists are invited to deliver seminars at DIAG each year. Below is a list of seminars for the year 2013, in chronological order. Also the Workshops organized at DIAG are reported, with the exception of the project meetings.

- February 1, Ingmar Weber, Qatar Institute of Technology, Qatar: Political Polarization in Web Search and on Twitter.
- February 4: WSDM 2013 - 6th ACM International Conference on Web Search and Data Mining - <http://wsdm2013.org>
- February 21, Aida Huerta, National Autonomous University of Mexico, Mexico: Modeling and Simulation Applied to the Design, Analysis and Optimization of Complex Systems.
- March 1, More@DIAG seminar: Workshop on the Microeconomics and Management of Social Enterprises - <http://www.dis.uniroma1.it/node/6551>
- March 13, More@DIAG seminar, Roberto Lucchetti, Politecnico di Milano, Italy: Using Game Theory in Molecular Biology.
- March 19, More@DIAG seminar, Léopold Simar, Université Catholique de Louvain, France: Efficiency Analysis: Recent Developments and Perspectives.
- March 27, More@DIAG seminar, Vittorio Latorre, DIAG, Ph.D. student: Canonical Duality Theory.

- May 2, Raymond Sheh, Robotlit LLC, Gaithersburg, Maryland, USA: Applying Measurement Science to Advance the State of Response Robotics.
- May 3, Charles Woodward, VTT Technical Research Centre of Finland, Finland: Augmented Reality Applications, Tracking and Rendering.
- May 10, More@DIAG seminar, Maurizio Falcone, Dipartimento di Matematica, Sapienza University of Rome, Italy: Sviluppi recenti nella approssimazione di problemi di controllo e giochi attraverso la programmazione dinamica.
- May 13, Eli Upfal, Brown University, USA: Statistical Learning Theory Meets Big Data: Randomized Algorithms for Extracting Frequent Itemsets and Association Rules.
- May 20, Paolo Robuffo Giordano, CNRS-IRISA Rennes, France: A Framework for Nonlinear Active Estimation with Applications to Structure from Motion.
- June 5, Alexander Kleiner, Dept. of Computer and Information Science, Linköpings Universitet, Linköping, Sweden: Collaborative Robotics.
- June 12, José M. F. Moura, Carnegie Mellon University, USA: Signal Processing on Graphs.
- June 18, Fazel Famili, NRC of Canada and University of Ottawa, Canada: Analyzing Imbalanced Data in Life Sciences.
- June 19, Alessandro Solimando, Università di Genova, Italy: Automata-based Static Analysis of XML Document Adaptations.
- June 25, Chih-Jen Lin, National Taiwan University, Taiwan: Optimization Methods for Large-Scale Linear Classification.
- July 2, Giacinta Santo, SELTA B.U. Defence & CyberSec, Italy: Certificazione della sicurezza di prodotti e sistemi ICT.
- July 3, More@DIAG seminar, Anming Zhang, University of British Columbia, Canada: Monopoly Price Discrimination when Markets are Interdependent.
- July 4, More@DIAG seminar, Luiza Badin, Bucharest University of Economic Studies, Romania: CondEff: A Toolbox for Conditional Efficiency Measurement.
- July 4, More@DIAG seminar, Giovanni Cesaroni, Dipartimento Sviluppo Economie Territoriali, Presidenza del Consiglio dei Ministri, Italy: A Simple Method for the Determination of Scale Economies in Non-parametric Models.
- July 10, Leonid Libkin, School of Informatics - University of Edinburgh, UK: Incomplete Information, Naive Evaluation, and Homomorphism Preservation.
- September 9, Alberto Pretto, DIAG, Sapienza University of Rome, Italy: Visual SLAM: Sparse, Dense and Inertial Aided Mapping.

- September 19, More@DIAG workshop, Gali Halevi, Elsevier NY, USA: An analysis of downloading practices in research institutions.
- September 19, More@DIAG workshop, Henk F. Moed, Elsevier, Amsterdam, Netherlands: Correlations between article downloads and citations.
- September 19, More@DIAG workshop, Cinzia Daraio, DIAG, Sapienza Università di Roma, Italy: Comparing disciplinary profiles of research systems: methodology and perspectives.
- September 25-26: HFR 2013 - 6th International Workshop on Human-Friendly Robotics - <http://hfr13.wordpress.com>
- October 14, Ales Leonardis, University of Birmingham, UK: Hierarchical Compositional Representations of Object Structure.
- October 28, Catherine Pelachaud, Institut Mines-Telecom, Telecom ParisTech, CNRS LTCL, France: Communicating with Socio-emotional Agents.
- October 29, More@DIAG Seminar, Victor Podinovski, Warwick Business School, UK: Weight restrictions and Production Trade-offs in Data Envelopment Analysis.
- November 6, Piotr Sankowski, University of Warsaw, Poland: Algebraic Algorithms for b-Matching, Shortest Undirected Paths, and f-Factors.
- November 11, Antonis Argyros, University of Crete and FORTH: Tracking the Motion of Human Hands.
- November 20, Aleksander Madry; Jakub Łacki; Dariusz Leniowski, University of Warsaw, Poland: Seminars on Graph Algorithms.
- November 25, Timothy Bretl, University of Illinois at Urbana, USA: Principles of Optimality in Robotics and Neuroscience.
- November 27, Krzysztof Onak, IBM T.J. Watson Research, USA: Parallel Algorithms for Geometric Graph Problems.
- November 28: euRobotics week: Robots@Diag - <http://www.eu-robotics.net/eurobotics-week/events-2013/robotsdiag.html>
- December 3, Danilo Bilotta, Dipartimento della Protezione Civile, Italy: Il sistema della Protezione Civile: gestione delle crisi e delle emergenze in Italia ed all'estero.
- December 5, Seth Hutchinson, University of Illinois at Urbana, USA: A Hyperbelief Space Approach to Computing Optimal Policies for POMDPs.
- December 10, Michele Emmer, Dipartimento di Matematica, Sapienza University of Rome, Italy: Numeri immaginari: la matematica al cinema.

- December 19, Annie Ruimi, University of California Santa Barbara, USA: Thread Simulations for Biomedical Applications.
- December 19, Francesco Orabona, TTI Chicago, USA: Adaptation in Online Learning through Dimension-Free Exponentiated Gradient.

## 2.7 Awards and Recognitions

- Daniela Berardi, Diego Calvanese, Giuseppe De Giacomo, Maurizio Lenzerini, Massimo Mecella: ICSSOC award for the most influential paper for the last ten years (2003 - 2012), 2013.
- Diego Calvanese, Giuseppe De Giacomo, Marco Montali, Fabio Patrizi: Best Paper Award at the 7th International Conference on Web Reasoning and Rule Systems (RR 2013), 2013.
- Giuseppe De Giacomo: received a Sapienza Award, 2013.
- Alessandro De Luca and Fabrizio Flacco: Best Video Award Finalist at the IEEE/RSJ International Conference on Intelligent Robots and Systems, 2013.
- Alessandro De Luca: Vice-President for Publication Activities of the IEEE Robotics and Automation Society, 2012-2013.
- Domenico Laise: Highly Commended Paper Award from The Journal of Intellectual Capital, 2013.
- Vittorio Latorre and Simone Sagratella: Best Paper Prize for young scientists at the World Congress on Global Optimization, Huangshan City, China, July 2013
- Stefano Leonardi: received a Google Research Award, 2013.

## 2.8 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, ending 31-05-2013
- FP7-CP € 729.424, NIFTi - Natural human-robot cooperation in dynamic environments, F. Pirri, ending 31-12-2013

- FP7-CP € 815.392, SAPHARI - Safe and Autonomous Physical Human-Aware Robot Interaction, A. De Luca, ending 31-10-2015
- FP7-CP € 173.608, SMARTV2G - Smart Vehicle to Grid Interface, C. Mannino, ending 31-05-2014
- FP7-CP € 127.800, ECHORD - European Clearing House for Open Robotics Development - S4R, D. Nardi, ending 30-09-2013
- FP7-CP € 372.177, MULTIPLEX - Foundational Research on MULTIlevel comPLEX networks and systems, S. Leonardi, ending 31-10-2016
- FP7-CP € 802.488, OPTIQUE - Scalable End-user Access to Big Data, R. Rosati, ending 31-10-2016
- FP7-CP € 62.680, GreenerBuilding - An ubiquitous embedded systems framework for energy-aware buildings using activity and context knowledge, M. Mecella, ending 31-08-2013
- FP7-CP € 348.880, Smart-Vortex - scalable semantic product data stream management for collaboration and decision making in engineering, T. Catarci, ending 30-09-2014
- FP7-IP € 285.680, FI-WARE - Future Internet Core Platform, F. Delli Priscoli, ending 30-04-2014
- FP7-IRSES € 18.000, EUSACOU - European south american network on combinatorial optimization under uncertainty, A. Marchetti Spaccamela, ending 31-07-2014
- FP7-NOE € 297.600, PROMISE - Participative research laboratory for multimedia and multilingual information systems evaluation, G. Santucci, ending 31-08-2013
- FP7-People/2009-IIPP € 83.500, MANON - Methods for advanced multi-objective optimization of complex nanoscale circuits, G. Di Pillo, ending September 2014
- ARTEMIS € 240.000, nSHIELD - new embedded systems architecture for multi-layer dependable solutions, F. Delli Priscoli, ending 31-08-2014
- ERC-STG € 332.200, PAAI — Practical approximation algorithms, S. Leonardi, ending 30-11-2014
- LLP KA3 € 59.863, E-Learning Fitness, U. Nanni, ending 31-12-2013
- ARTEMIS € 240.000, nSHIELD - new embedded systems architecture for multi-layer dependable solutions, F. Delli Priscoli, ending 31-08-2014
- FP7-CP € 438.780, ROVINA - Robots for Exploration, Digital Preservation and Visualization of Archeological Sites, G. Grisetti, ending 31-07-2016

- FP7-CSA € 323.675, ROCKIN - Robot Competitions Kick Innovation in Cognitive Systems and Robotics, D. Nardi, ending 31-12-2015
- FP7-CSA € 56.346, CROSSOVER - Bridging Communities for Next Generation Policy-Making, R. Baldoni, ending 30-06-2013
- CIPS € 95.962, CRISADMIN - CRITICAL Infrastructure Simulation of ADvanced Models on Interconnected Networks resilience, R. Baldoni, ending 31-08-2014
- FP7-CP € 753.968, TRADR - Long-Term Human-Robot Teaming for Robot-Assisted Disaster Response, F. Pirri, ending 31-12-2017

#### **Contracts with Italian Institutions**

- Fondazione S. Lucia € 81.000, Progetto ARISLA Brain-computer interface devices to support individual autonomy in locked-in individuals, M. Mecella, ending 31-10-2013
- MISE, Industria 2015 € 115.228, Progetto di innovazione industriale Nuove Tecnologie per il Made in Italy "Speaky Acutattile", D. Nardi, ending 31-05-2014
- MISE, Industria 2015 € 90.630, Progetto di innovazione industriale Nuove Tecnologie per il Made in Italy "I-Mule", A. De Luca, ending 31-12-2014
- MIUR - PON € 838.828, PLATINO - PLATform for INnOvative services in future internet, F. Delli Priscoli, ending 30-06-2015

#### **Contracts with Companies**

- NICA SRL € 51.412 Studio/ricerca nell'ambito del progetto DE.DOC concernente la realizzazione di un progetto di ricerca industriale per definire le metodologie l'organizzazione e gli strumenti in grado di rendere efficace e di rapida attuazione la dematerializzazione documentale in una organizzazione complessa e molto specifica come l'azienda ospedaliera. Progetto FILAS RS-2009-1045. M. Lenzerini, ending 31-12-2013
- CREASYS SRL € 117.500 Studio/ricerca riguardante metodi e strumentio per la mappatura ontologica di contenuti non strutturati sui interfacce avanzate di ricerca di informazioni in sistemi basati su ontologie. Bando Co-research indetto dalla FILAS. M. Lenzerini, ending 31-12-2013
- A.N.A.V. - Associazione Nazionale Autotrasporto Viaggiatori € 30.000 Studio/ricerca concernente gli aspetti metodologici per la deteminazione del costo standard nei servizi di trasporto pubblico locale su gomma, urbano ed extraurbano, A. Nastasi, ending 20-03-2013
- THALES ALENIA SPACE ITALIA SPA € 52.000 Esecuzione di attività di formazione nell'ambito del Programma GAPACOM, D. Nardi, ending 16-07-2013

- THALES ALENIA SPACE ITALIA SPA € 9.720 Studio/ricerca sul tema: Studio e Definizione di Tecniche di Gestione Sistemi SatCom inizio 12/11/2012 - nell'ambito del Programma Iris/ANTARES - B2 phase, F. Delli Priscoli, ending 11-05-2013
- THALES ALENIA SPACE ITALIA SPA € 14.580 Studio/ricerca sul tema: Studio e Definizione di Tecniche di Gestione Sistemi SatCom nell'ambito del CT Pubblico 10109 del 28/12/2011 tgra TAS e Ministero Difesa, F. Delli Priscoli, ending 31-07-2013
- THALES ALENIA SPACE ITALIA SPA Studio/ricerca sul tema: Studi Innovativi di Missione e di Rete di nuova Generazione nell'ambito del Programma di Studio MERCURE CT Pubblico 20118 tra TAS e Ministero della Difesa, F. Delli Priscoli, ending 06-11-2013
- ADF SERVICE SRL € 8.000 Studio ricerca concernente l'analisi dei costi e dei risultati economico-finanziari di un opportuno campione delle imprese di distribuzione farmaceutica e la simulazione degli effetti di possibili mutamenti nella remunerazione che il SSN prevede per la distribuzione di farmaci in regime DPC, C. Leporelli, ending 06-03-2013
- MINISTERO DELL'INTERNO - PREFETTURA DI ROMA € 9.920 Studio/ricerca: Realizzazione di un intervento di analisi dei fabbisogni per la Gestione del Back-Office dello Sportello Unico per l'Immigrazione della Prefettura di Roma, A. Avenali, ending 12-04-2013
- SENSICHIPS SRL € 4.000 Studio/ricerca: Software Dimostrativo, Scheletro di API e di interfaccia a Driver USB per il progetto SENSIPLUS, R. Beraldi, ending 25-05-2013
- SILICONDEV SRL € 30.000 Esecuzione di una ricerca nell'ambito del progetto: Business Simulation for Healthcare - BuS-4H RIF. FILAS-CR-2011-1137, M. Roma, ending 15-04-2014
- ENEL SERVIZI SRL € 19.000 Studio/ricerca: Servizio di Utility Of The Future presso l'università La Sapienza - Contratto n. 1400055612, A. Nastasi, ending 19-01-2014
- CIVIT € 10.000 Contratto per prestazione professionale: Attività di esperto in materia di analisi dell'evoluzione del contesto economico finanziario ed approfondimento delle tematiche connesse alla valutazione della performance organizzativa ai fini della redazione della relazione sulla performance e la relazione 2012, G. Catalano, ending 31-12-2013
- TELECOM ITALIA SPA € 249.855 Sviluppo di una ontologia e mapping tra ontologia e sorgenti di dati (Ricerca nell'ambito di un progetto che ha come scopo lo sviluppo di una ontologia relativa ai concetti di interesse per la propria funzione organizzativa Open Access), M. Lenzerini, ending 15-06-2014

- DUEL SPA € 57.500 Esecuzione di una ricerca concernente l'analisi di dati del traffico per applicazioni di info-mobilità nell'ambito del progetto FILAS SpA(prot. 0012578 del 21/10/2013 RS/MT PEC), L. Iocchi, ending 23-01-2015
- SMARTCARE SRL € 90.000 Attività di ricerca sul tema: Sviluppo dell'ontologia del debito pubblico e mapping tra ontologia e sorgenti di dati, M. Lenzerini, ending 31-03-2014  
GS AUTOMATION SPA € 32.000 Attività di ricerca riguardante lo sviluppo del sistema: DATA ANALYZER & ACQUISITION SYSTEM - Avviso pubblico Progetti di R&S in collaborazione, da parte delle PMI del Lazio di cui al POR FESR Lazio 2007/2013 ASSE I-Attività 1- Prot. FILAS-CR-2011-1372 CUP F85C13001220007, A. Pietrabissa, ending 30-06-2015
- THALES ALENIA SPACE ITALIA SPA € 14.040 Attività di ricerca relative alla: Realizzazione del Segmento Terrestre per il programma ATHENA-FIDUS nell'ambito del CT pubblico 10109 28/12/2011 tra TAS e Ministero Difesa, F. Delli Priscoli, ending 17-06-2014

#### **Research Agreements (Convenzioni)**

- ADF Service srl, ending 14-10-2015
- CESOP Communication srl, ending 30-06-2015
- CINI Consorzio Interuniversitario Nazionale per l'Informatica, ending 24/04/2014
- CISIT Srl, ending 12/12/2013
- EUROGROUP Consulting Italia srl, ending 28-11-2013
- Fondazione S. Lucia, ending 27-07-2015
- BRAINSIGNS SRL, ending 14-06-2014
- PROJECT MANAGEMENT INSTITUTE, ending 31-07-2013
- ISTITUTO AFFARI INTERNAZIONALI - IAI, ending 09-09-2016
- TEXAS ENGINEERING EXPERIMENT STATION, ending 15-10-2015

## 3 Research

### 3.1 Algorithm Design and Engineering

#### Research lines:

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

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

**PhD Students:** Daniele Cono D'Elia, Donatella Firmani.

**Post Docs:** Luigi Laura.

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;

- Performance Engineering: design and implementation of methodologies and tools for analyzing and optimizing software systems;
- 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;
- Algorithmic approaches for bioinformatics and elearning: application of algorithmic models and techniques to bioinformatics and elearning.

In the future we plan to tackle fundamental problems arising in emerging applications involving the analysis and optimization of networks, real-time systems, scheduling and resource allocation, as well as in other areas. 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.
- Algorithmic approaches for bioinformatics and elearning: several models and techniques, studied and evolved within the area of algorithm engineering turned out to be very pervasive. In various contexts these has lead to effective solutions to

problems with complex structure. In the last years we have devised representations, based on graphs and hypergraphs, suitable to model processes and biological systems. Then, working with groups of researchers in other disciplines - such as bioinformatics and elearning - we aim at boosting research results in these areas.

### Projects:

- *AMANDA: Algorithmics for MAssive and Networked DAta* - February 2013, February 2017 - PRIN MIUR
- *eLF: eLearning Fitness* - January 2011, December 2013 - EU EACEA LLP ka3-ICT
- *EUSACOU* - January 2010, July 2014 - UE IRSES project

### Journals

- [1] Fabrizio Grandoni, Anupam Gupta, Stefano Leonardi, Pauli Miettinen, Piotr Sankowski, and Mohit Singh. Set covering with our eyes closed. *SIAM J. Comput.*, 42(3):808–830, 2013.
- [2] Graham Cormode and Donatella Firmani. A unifying framework for  $\ell_0$ -sampling algorithms. *Distributed and Parallel Databases*, pages 1–21, 2013.

### Conference proceedings

- [3] Aris Anagnostopoulos, Luca Becchetti, Bart de Keijzer, and Guido Schäfer. Inefficiency of games with social context. In Berthold Vöcking, editor, *SAGT*, volume 8146 of *Lecture Notes in Computer Science*, pages 219–230. Springer, 2013.
- [4] Aris Anagnostopoulos, Fabrizio Grandoni, Stefano Leonardi, and Andreas Wiese. Constant integrality gap lp formulations of unsplittable flow on a path. In Michel X. Goemans and José R. Correa, editors, *IPCO*, volume 7801 of *Lecture Notes in Computer Science*, pages 25–36. Springer, 2013.
- [5] Giorgio Ausiello, Donatella Firmani, and Luigi Laura. The (betweenness) centrality of critical nodes and network cores. In Roberto Saracco, Khaled Ben Letaief, Mario Gerla, Sergio Palazzo, and Luigi Atzori, editors, *IWCMC*, pages 90–95. IEEE, 2013.
- [6] Giorgio Ausiello, Paolo Giulio Franciosa, Giuseppe Francesco Italiano, and Andrea Ribichini. On resilient graph spanners. In Hans L. Bodlaender and Giuseppe F. Italiano, editors, *ESA*, volume 8125 of *Lecture Notes in Computer Science*, pages 85–96. Springer, 2013.
- [7] Sayan Bhattacharya, Elias Koutsoupias, Janardhan Kulkarni, Stefano Leonardi, Tim Roughgarden, and Xiaoming Xu. Near-optimal multi-unit auctions with ordered bidders. In Michael Kearns, R. Preston McAfee, and Éva Tardos, editors, *EC*, pages 91–102. ACM, 2013.

- [8] Vincenzo Bonifaci, Alberto Marchetti-Spaccamela, Nicole Megow, and Andreas Wiese. Polynomial-time exact schedulability tests for harmonic real-time tasks. In *RTSS*, pages 236–245. IEEE, 2013.
- [9] Vincenzo Bonifaci, Alberto Marchetti-Spaccamela, Sebastian Stiller, and Andreas Wiese. Feasibility analysis in the sporadic dag task model. In *ECRTS*, pages 225–233. IEEE, 2013.
- [10] Graham Cormode and Donatella Firmani. On unifying the space of  $\ell_0$ -sampling algorithms. In Peter Sanders and Norbert Zeh, editors, *ALENEX*, pages 163–172. SIAM, 2013.
- [11] Daniele Cono D’Elia and Camil Demetrescu. Ball-larus path profiling across multiple loop iterations. In Antony L. Hosking, Patrick Th. Eugster, and Cristina V. Lopes, editors, *OOPSLA*, pages 373–390. ACM, 2013.
- [12] Donatella Firmani, Giuseppe F. Italiano, Luigi Laura, and Federico Santaroni. Is timetabling routing always reliable for public transport? In Daniele Frigioni and Sebastian Stiller, editors, *ATMOS*, volume 33 of *OASICS*, pages 15–26. Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik, 2013.

#### PhD theses

- [13] Donatella Firmani. *Large-scale Graph Algorithms and Applications*. PhD thesis, Sapienza University of Rome, 2013.

### 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, Domenico Lembo, Daniele Nardi, Fabio Patrizi, Antonella Poggi, Riccardo Rosati, Stavros Vassos

**PhD Students:** Roberto Capobianco, Cristina Civili, Marco Console, Riccardo De Masellis, Paolo Felli, Guglielmo Gemignani, Lorenzo Lepore, Valerio Santarelli.

**Post Docs:** Gabriele Randelli, Domenico Fabio Savo, Josè Mora.

**Research grants:** Emanuele Bastianelli.

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 line developed in this group targets robots as embodied cognitive agents. Machine learning techniques are applied to build and refine controllers that implement complex robot behaviors. Moreover, *Human Robot Interaction* is addressed to acquire the knowledge needed for effective implementation of robot actions through a multi-modal interaction with the user. In particular, we focus on the construction of the so-called *semantic map*, which combines metric and symbolic representations of the environment. Moreover, we rely on a rich multi-modal interaction including speech, gesture and tactile communication.

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.

Members of the research group have been invited to organize various events, and to deliver keynote speeches at various conferences and workshops. The following is a list of such activities:

- Maurizio Lenzerini, "20 Years on Applied Ontology: A View from Knowledge Representation and Databases", invited talk at the panel "20th Anniversary of Applied Ontology", XIII Conference of the Italian Association for Artificial Intelligence, Torino, December 2013.
- Maurizio Lenzerini, "La ricerca di una logica per l'Italia", intervento invitato al convegno "Zetesis, la gioia della ricerca", Sala Convegni dell'Archivio Centrale di Stato, Roma, 21 novembre 2013.
- Domenico Lembo has been co-chair of the program committee of the 7th International Conference on Web Reasoning and Rule Systems, held in Mannheim, Germany, July 27-29, 2013.
- Giuseppe De Giacomo, Editorial Board Member of Artificial Intelligence, Elsevier.
- Giuseppe De Giacomo, Associate Editor of Journal of Artificial Intelligence Research (JAIR).

- Giuseppe De Giacomo, Guest editor of Special Issue on Description Logics for the Journal of Artificial Intelligence Research (JAIR) - October 2013.
- Giuseppe De Giacomo has been a Senior Program Committee Member of the 27th AAAI Conference on Artificial Intelligence (AAAI-13), July 14-18, 2013 in Bellevue, Washington, USA
- Giuseppe De Giacomo has been a Senior Program Committee Member of the 23rd International Conference on Artificial Intelligence (IJCAI-13), Beijing, China from August 3-9, 2013.
- Giuseppe De Giacomo is the program Chair of the 14th International Conference on Principles of Knowledge Representation and Reasoning (KR14), July 20-24, 2014 - Vienna, Austria.
- Giuseppe De Giacomo, "Linear Temporal Logics on Finite Traces: Reasoning, Verification, and Synthesis", 23rd International Conference on Automated Planning and Scheduling (ICAPS13), Rome, Italy, June 10-14, 2013.
- Daniele Nardi has been visiting Professor at Carnegie Mellon University, Computer Science Department, 2012.
- Daniele Nardi has been President of the RoboCup Federation, 2013.
- Daniele Nardi has been chair of the Robotics Track of the Autonomous Agents and Multi-Agent Systems, 2013.
- The SPQR team of humanoid soccer players obtained the 1st place in Iranian Open, the 3rd place in German Open, Magdeburg, and participated in RoboCup 2013, Eindhoven, 2013.

**Projects:**

- *OPTIQUE* - Scalable End-User Access to Big Data, November 2012 - October 2016 (EU FP7), Riccardo Rosati.
- *Joint project with Smartcare S.r.l.* : Modellazione ontologica per il sistema informativo del debito pubblico, Maurizio Lenzerini, September 2013 - March 2014.
- *SPIRITLETS: SPIRITLET-based Smart spaces*, Award Sapienza research project, November 2013 - April 2015.
- *Speaky Acutattile*, Ministero dello Sviluppo Economico (Industria 2015), Luigia Carlucci Aiello, Daniele Nardi, June 2011 - June 2014
- *Speaky for Robots*, EU FP7, ECHORD IP, Daniele Nardi, November 2011 - April 2013

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### 3.3 Combinatorial Optimization

**Research Lines:**

- Polyhedral Combinatorics
- Graph theory and Optimization
- Data Mining and Classification
- Telecommunication Network Design
- Scheduling and Job-shop Scheduling
- Computational Biology and Polymer Sequencing
- Satisfiability in Propositional Logic
- Information Reconstruction
- Portfolio Optimization
- Robust Optimization

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

**PhD students:** Gianpiero Bianchi, Alessandra Reale.

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 DIS 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 information reconstruction in large datasets, algorithms for classification based on propositional logic, algorithms for inconsistency selections.

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, Istituto Nazionale di Statistica (Istat), 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 and for portfolio management; algorithms for weighted matching and stable set problems; polyhedral properties of the stable set polyhedron and of interval and staircase matrices; optimization techniques for classification 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, progetto MIUR n. 2878
- Metodi di ottimizzazione su larga scala nelle telecomunicazioni, progetto PRIN 2008, n. 2008LLYXFS.
- Modelli Robusti di Ottimizzazione Lineare e Intera per Problemi di Data Mining - Progetto di Ateneo 2013

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#### **PhD theses**

- [11] Bianchi G., Optimization Techniques for Data Mining and Information Reconstruction, Ph.D. Thesis in Operations Research, 2013.

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

- [12] Bruni R., Detti P., A Flexible Discrete Optimization Approach to the Physician Scheduling Problem, submitted to *Operations Research for Health Care*, 2013.

### 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
- People Centric Sensing

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

**PhD Students:** Khalil M.H. Al Massri, Lorenzo Bergamini, Francesco Ficarola, Mario Paoli

**Post Doc:** Ugo Colesanti.

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 and we have about 600 active tags to collect and analyse the so called proximity graph, namely a graph in which nodes are users and there is a link between two nodes if their are in proximity). 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.

### Recent Projects:

- *PANORAMA: Coordinated Action on Pervasive Adaptation* - February 2008, January 2011 - EU FP7 Coordinated action.
- *FRONTS: Foundations of Adaptive Networked Societies of Tiny Artefacts* - February 2008, January 2011 - EU FP7 IP.
- *AEOLUS: Algorithmic principles for building overlay computers* - September 2006, February 2010 - EU FP6.
- *PharmAID: smart RFID for tracking medicines* - June 2010, December 2012 - EUREKA Eurostars.
- *TETRIS: ervizi innovativi Open Source su TETRA* - December 2010, December 2013 - MIUR PON01\_00451.
- *provinciaWSN: estensione della rete WiFi della provincia di Roma per mezzo di reti di sensori wireless* - Progetto Ateneo 2013

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- [3] Becchetti L., Filipponi L., and Vitaletti A. Privacy support in people-centric sensing. *Journal of Communications*, 7(8):606–621, 2012.

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- [11] Ugo Maria Colesanti, Antonio Lo Russo, Mario Paoli, Chiara Petrioli, and Andrea Vitaletti. Structural health monitoring in an underground construction site: the roman experience. In *Proceedings of the 11th ACM Conference on Embedded Network Sensor Systems, SenSys '13*, page 46, 2013.
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#### **Submitted papers, technical reports and others**

- [23] Luca Becchetti, Andrea Clementi, Emanuele Natale, Francesco Pasquale, Riccardo Silvestri, and Luca Trevisan. Simple dynamics for majority consensus. *arXiv preprint arXiv:1310.2858*, 2013. Submitted.

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

#### Research lines:

- Human Motion Analysis, Gesture Recognition, Physics based methods
- Saliency Prediction, Visual Attention, Action Recognition
- Dense Map Merging and Fusion, Meshing, 3D Surface Reconstruction
- Scene Representation, Interpretation and Understanding
- Terrain Traversability in Rescue Environments
- Recognition of Peri-Urban Areas in X Band SAR Images
- Patterns for Zooming Camera Calibration
- Learning of Visual Object Categories
- Control for Polyarticulated Self-Powered Hand Prostheses
- Adaptive, Flexible Cognitive Control under Task Switching for Rescue Robots
- 3D Motion Planning for Articulated Unmanned Tracked Vehicles
- Visual Media Analysis, Indexing, Classification and Retrieval
- Management of Digital Resources
- Augmented Reality and Computer Animated Virtualization

**Members:** Marco Fratarcangeli, Barbara Caputo, Luca Iocchi, Fiora Pirri (leader), Marco Schaerf.

**PhD Students:** Bruno Cafaro, Federico Ferri, Mario Gianni, Matteo Menna, Valsamis Ntouskos, Alessio Vaudi, Nadine Abu Rumman.

The problem of Human Action Recognition is investigated, in our research work, within Motion Capture sequences. In this context, we investigated methods based on Gaussian Process Latent Variable Models and Alignment Kernels. We propose a new discriminative latent variable model with back-constraints induced by the similarity of the original sequences. We compare the proposed method with methods based on Dynamic Time Warping and with V-GPDS models, which are able to model highly dimensional dynamical systems.

In the coherence theory of attention, introduced by Rensink, O'Regan, and Clark (2000), a coherence field is defined by a hierarchy of structures supporting the activities taking place across the different stages of visual attention. At the interface between low level and mid-level attention processing stages are the proto-objects; these are generated in parallel and collect features of the scene at specific location and time. These structures

fade away if the region is no further attended by attention. This research work aims to build methods to computationally model these structures, on the basis of data collected in dynamic 3D environments via the Gaze Machine, a gaze measurement framework.

3D Terrain understanding and structure estimation is a crucial issue for robots navigating rescue scenarios. Unfortunately, large scale 3D point clouds provide no information about what is ground, and what is top, what can be surmounted and what can be not, what can be crossed, and what is too deep to be traversed. In this context, this research work mainly concentrated in providing methods for point cloud structuring which can lead to a definition of traversability cost maps.

The aim of the research activities, concerning with the analysis of Synthetic Aperture Radar (SAR) images in X-band, is to classify different zones in peri-urban forestries integrating information from different sources. An integration of image segmentation and machine learning methods is studied to classify different zones of peri-urban forestries (e.g., trees canopies, lawns, water pounds, roads), exploiting the relation between the gray level signal properties of X-band images and the smoothness and roughness of the ground.

Camera calibration is a necessary step in order to develop applications that need to establish a relationship between image pixels and real world points. Usually, for non-zooming cameras, the calibration is carried out by using a grid pattern of known dimensions (e.g., a chessboard). However, for cameras with zoom functions, the use of a grid pattern only is not sufficient, because the calibration has to be effective at multiple zoom levels and some features (e.g., corners) could not be detectable. This research activity focuses on developing calibration methods based on novel calibration patterns, specifically designed for zooming cameras.

Learning a visual object category from few samples is a compelling and challenging problem. In several real-world applications collecting many annotated data is costly and not always possible. However a small training set does not allow to cover the high intraclass variability typical of visual objects. In this condition, machine learning methods provide very few guarantees. This research activity concentrates on discriminative model adaptation algorithms able to proficiently learn a target object with few examples, relying on other previously learned source categories.

The main means of control for polyarticulated self-powered hand prostheses is surface electromyography (sEMG). In the clinical setting, data collected from two electrodes are used to guide the hand movements selecting among a finite number of postures. Machine learning has been applied in the past to the sEMG signal (not in the clinical setting) with interesting results, which provide more insight on how these data could be used to improve prosthetic functionality. However, developing a finer control requires a longer training period. A desirable characteristic would be to shorten the time needed by a patient to learn how to use the prosthesis. To this aim, our research work focuses on exploiting methods to reuse past experience, in the form of models synthesized from previous subjects, to boost the adaptivity of the prosthesis.

Modeling cognitive control is a major issue in robot control, and it is about deciding when a task cannot succeed and a new task need to be initiated. These decisions are induced by incoming stimuli alerting of events taking place while the robot is executing its duties.

The research work on modeling robot adaptive behaviors, under salient stimuli, exploits the human inspired paradigm of shifting and inhibition, underlying task switching.

Tracked vehicles are currently used in search and rescue, military, agricultural and planetary exploration applications where terrain conditions are difficult and unpredictable. They are better suited for such tasks than wheeled vehicles due to the larger contact area of tracks with the ground, which provides better traction on harsh terrains. These environments are often inaccessible or considered too dangerous for humans to operate in, thus requiring the tracked vehicle to be endowed with autonomous navigation, safe locomotion and human-robot interaction capabilities to assist humans in complex tasks such as rescue, scouting or transportation. To cope with this challenging task, our research activities pursue to develop control models to allow articulated tracked vehicles to autonomously follow 3D paths, within cluttered environments, adapting their morphology to the complexity of the terrain.

The research work, concerning the management of digital resources, explores the applicability of the SDL metadata framework to support preservation, management and dissemination of the Sapienza Digital Library (SDL) resources. The applicability study has been proved to be useful to improve the SDL interoperability in the management of the differences in information granularity, and to fulfil the lack or to avoid the waste of information.

Within the context of our research activities, Augmented Reality is become a compelling technology mainly for the interactive 3D visualization of archaeological sites on handheld devices and for building of complex planning scenarios for robots, eliminating the need to model the dynamics of both the robot and the real environment as it would be required by whole simulation environments. The latter application constitutes an important research test-bed for robots, meeting the needs to test and experiment complex robot behaviors using such a dynamic and rich perceptual domain.

#### **Projects:**

- *NIFTi - Natural human-robot cooperation in dynamic environments* - 2010, 2014 - EU FP7 IP.
- *TRADR - Long-Term Human-Robot Teaming for Robot Assisted Disaster Response* - 2014, 2018 - FP7 ICT 609763.
- *Surgical Threads Simulations Based on a Novel Information-Theory Approach* - 2012, 2014 - NPRP5-353 2 138.

**Exhibitions:** Innorobo Fair (Lyon), Maker Faire (Rome), euRobotics Week (Rome), EXPO21XX (On-line exhibition).

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- [22] Pizzoli, M., Visual Saliency in the Wild: Moving the Analysis of Gaze Behaviors to Three-Dimensional, Unstructured Environments, Ph.D. thesis, Department of Computer, Control and Management Engineering A. Ruberti, Sapienza University of Rome, 2013.

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- [24] Bourlard, H., Caputo, B., Popescu-Belis, A., Medical image annotation, Technical Report, EPFL, 2013.

### 3.6 Continuous Optimization

**Research lines:**

- Nonlinear Optimization
- Derivative Free Methods
- Global Optimization
- Semidefinite Programming
- Variational Inequalities
- Mixed Integer Nonlinear Programming
- Big Data Optimization
- Parallel and distributed optimization methods
- Game Engineering
- Neural Networks and Support Vector Machines
- Engineering Design Optimization
- Resource allocation in communication networks

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

**PhD Students:** Cristofari Andrea, Umberto Dellepiane, Andrea Ianni, Andrea Manno, Stefania Renzi.

**Post Docs:** Marianna De Santis, Lorenzo Lampariello, Vittorio Latorre, Simone Sagratella.

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:

- *MANON: Methods for Advanced multi-objective optimization of complex NANoscale circuits* - April 2010, March 2012 - UE FP7/PEOPLE.
- *BuS-4H: Business Simulation for Healthcare* - April 2013, April 2014.

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- [13] Scutari G., Facchinei F., Song P., Palomar D., and Pang J.-S. Decomposition by partial linearization: Parallel optimization of multi-agent systems. *IEEE Transactions on Signal Processing*, 2013. Electronic version. DOI:10.1109/TSP.2013.2293126

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- [15] Ciccazzo A., Latorre V., and Di Pillo G. Support Vector Machines for Real Consumer Circuits In *Proceedings of The Eighth International Conference on Bio-Inspired Computing: Theories and Applications (BIC-TA)*, pages 1199-1207, Springer Berlin Heidelberg, 2013.
- [16] Huerta A., Brizi S., Elizondo M., and Roma M. Analyzing the main and the second order effects of operational policies on the warehouse productivity. In *Proceedings of the 2013 Winter Simulation Conference*, pages 3950–3951. IEEE, 2013.
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- [19] Cardellini V., Personé V. D., Di Valerio V., Facchinei F., Grassi V., Presti F. L., and Piccialli V. A game-theoretic approach to computation offloading in mobile cloud computing. Submitted to *Mathematical Programming*.

- [20] Dellepiane U., Palagi L. Using SVM to combine global heuristics for the Standard Quadratic Problem. Submitted to *European Journal of Operations Research*.
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- [23] Facchinei F., Kanzow C., Karl S., and Sagratella. S. The semismooth Newton method for the solution of quasi-variational inequalities. Submitted to *Computational Optimization and Applications*.
- [24] Facchinei F., Pang J.-S., and Palomar D. Real and complex monotone communication games. To appear in *IEEE Transaction on Information Theory*.
- [25] Facchinei F., Pang J.-S., and Scutari G. Non-cooperative games with minmax objectives. To appear in *Computational Optimization and Applications*.
- [26] Facchinei F., Sagratella S., and Scutari G. Flexible parallel algorithms for big data optimization. To appear in the Proceedings of the 2014 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP).
- [27] Latorre V., and Gao D. Y. Canonical Dual Solutions to Nonconvex Radial Basis Neural Network Optimization Problem. To appear in *Neurocomputing*.
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### 3.7 Data Management and Service-Oriented Computing

#### Research lines:

- Data Integration and Exchange
- Ontology Based Data Management
- Data Warehousing, Data Quality and Data Cleaning
- 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, Stavros Vassos.

**PhD Students:** Mario Caruso, Marco Console, Cristina Civili, Riccardo De Masellis, Claudio Di Ciccio, Paolo Felli, Francesco Leotta, Lorenzo Lepore, Andrea Marrella, Alessandro Russo, Valerio Santarelli.

**Post Docs:** Marco Ruzzi, Domenico Fabio Savo, José Mora.

Our interest in Data Management dates back to the '80s, when the main research topics addressed by our group 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. Ontology-based data management (OBDM) is a promising direction for addressing the above challenges. The key idea of OBDM is to resort to a three-level architecture, constituted by the ontology, the sources, and the mapping between the two, where the ontology is a formal description of the domain of interest, and is the heart of the whole system. With this approach, the integrated view that the system provides to information consumers is not merely a data structure accommodating the various data at the sources, but a semantically rich description of the relevant concepts in the domain of interest, as well as the relationships between such concepts. Other Data Management topics related to Information Integration are also investigated, including View-based Query Processing, Data Warehousing, Data Quality, and Data Cleaning.

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

- (i) posing the semantics of the application domain at the center of the scene,
- (ii) combining the management of data with the management of the processes and services using such data in the organization, and
- (iii) 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.

In 2013, members of the research group have been invited to organize various events, and to deliver keynote speeches at various conferences and workshops. The following is a list of such activities:

- Tiziana Catarci has been the general Chair of the 9th Italian Research Conference on Digital Libraries (IRCDL 2013) that took place in Rome, Italy, January, 31 - February, 1, 2013.
- Antonella Poggi has been the program co-Chair of the 9th Italian Research Conference on Digital Libraries (IRCDL 2013).
- Tiziana Catarci has chaired the Panel “Evaluating Cultural Heritage Information Access Systems” at 9th Italian Research Conference on Digital Libraries (IRCDL 2013).
- Stavros Vassos has co-chaired the “3rd Planning in Games Workshop” of the 23rd International Conference on Automated Planning and Scheduling (ICAPS 2013) that took place in Rome, Italy, 10-14 June, 2013.
- Massimo Mecella was the program Chair of the 6th IEEE International Conference on Service Oriented Computing & Applications (SOCA 2013) that took place in Kauai, USA, 16-18 December, 2013.

- Andrea Marrella was co-Chair of the 2nd International Workshop on Knowledge-intensive Business Processes (KiBP 2013), co-located with the 6th IEEE International Conference on Service Oriented Computing & Applications (SOCA 2013) that took place in Kauai, USA, 16 December, 2013.
- Massimo Mecella, "Challenges in Knowledge-intensive Processes: Mining for Semi-structured Information and Providing Run-time Automated Adaptation", keynote talk at the 2nd International Workshop on Knowledge-intensive Business Processes (KiBP 2013).
- Maurizio Lenzerini, "Ontology-based data management", keynote talk at the Semantic Days 2013 - Business Intelligence and Semantics, Stavanger, Norway, 2013.
- Maurizio Lenzerini, "Ontology-based Data Management", ACM Sigmod Blog, ACM Special Interest Group in Data Management, <http://wp.sigmod.org/?p=871>, May 2013.
- Maurizio Lenzerini has been the program co-Chair of the 7th Alberto Mendelzon International Workshop on Foundations of Data Management, AMW 2013.
- Maurizio Lenzerini was in the ACM SIGMOD Awards Committee, 2013.
- Maurizio Lenzerini was in the Executive Committee of the ACM Principles of Database Systems (PODS), 2013.
- Fabio Patrizi co-chaired the PhD Symposium of the 11th International Conference on Service Oriented Computing (ICSOC 2013), held in Berlin on Dec 2, 2013.

**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).
- Project funded by Regione Lazio: *Integrazione semantica di dati e servizi per le aziende in rete*, 2011 - 2014.
- 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*, 2009-2013.
- 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.
- Research project funded by Sapienza: "Efficiency, Effectiveness and Impact of Schools and Universities", November 2013 - October 2014.

- GenData2020 - Data-driven Genomic Computing, MIUR PRIN 2010, February 2013 - January 2016.
- Research project funded by Telecom Italia: "Sviluppo di una ontologia per la rete di accesso e mapping tra ontologia e sorgenti di dati", September 2013 - April 2014.

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- [7] Guercio M. and Salza S. *Digital Libraries and Archives, 8th Italian Research Conference, IRCDL 2012 Bari, Italy, February 9-10, 2012 Revised Selected Papers*, volume 354, chapter Managing Authenticity through the Digital Resource Lifecycle, pages 249–260. Springer-Verlag, Berlin, Heidelberg – DEU, 2013.

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- [9] Catarci T., Ferro N., and Poggi A., editors. *Bridging Between Cultural Heritage Institutions - 9th Italian Research Conference, IRCDL 2013, Rome, Italy, January 31 February 1, 2013, Revised Selected Papers*, volume 385 of *Communications in Computer and Information Science*. Springer, 2013.

- [10] Kolaitis P. G., Lenzerini M., and Schweikardt N., editors. *Data Exchange, Integration, and Streams*, volume 5 of *Dagstuhl Follow-Ups*. Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik, 2013.

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- [11] Antonioli N., Castanò F., Civili C., Coletta S., Grossi S., Lembo D., Lenzerini M., Poggi A., Savo D. F., and Virardi E. Ontology-based data access: The experience at the italian department of treasury. In *Proc. of the Industrial Track of the 25th International Conference on Advanced Information Systems Engineering (CAISE 2013)*, CEUR Workshop Proceedings, 2013.
- [12] Calvanese D., De Giacomo G., Montali M., and Patrizi F. Dynamic Systems Based on Description Logics: Formalization, Verification, and Synthesis. In *Proc. of the 26th International Workshop on Description Logics (DL 2013)*, pages 573–586, 2013.
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### 3.8 Distributed Systems

**Research lines:**

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

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

**PhD Students:** Leonardo Aniello, Claudio Ciccotelli, Antonella Del Pozzo, Giuseppe Antonio Di Luna, Fabio Petroni, Mara Sorella.

**Post Docs:** Adriano Cerocchi, Luca Montanari, Marco Platania.

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 supercomputing, 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 security, namely *CoMiFin* and *PANOPTESSEC*, that motivate the foundational research.

#### Projects:

- *PANOPTESSEC* - November 2013, September 2016 - EU IP FP7
- *DMI - Digital Market Intelligence* - October 2013, April 2015 - Regional project.
- *TENACE, Protecting National Critical Infrastructures from Cyber Threats* - February 2013, January 2016 - PRIN MIUR.
- *SM4All, Middleware Platform for Pervasive and Immersive Environments For-ALL* - September 2008, August 2011 - EU Strep FP7.
- *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 FP7.
- *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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- [12] Baldoni R., Bonomi S., Di Luna G. A., Montanari L., and Sorella M. Understanding (Mis)information Spreading for improving Corporate Network Trustworthiness. In *Proceedings of the 14th European Workshop on Dependable Computing (EWDC)*, 2013.
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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 (leader), Francesco Quaglia.

**PhD Students:** Alessandro Pellegrini, Sebastiano Peluso, Diego Rughetti, Roberto Vitali.

**Post Docs:** Pierangelo Di Sanzo, Roberto Palmieri.

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.
- *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

### Journals

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### Articles in books

- [2] Barreto J, Pierangelo Di Sanzo, Palmieri R, and Romano P. *Cloud-TM. Data Intensive Storage Services for Cloud Environments.*, Ed. Dimosthenis Kyriazis, Athanasios Voulodimos, Spyridon V. Gogouvtis, and Theodora Varvarigo, p. 192–224. IGI Global, Hershey PA – USA, 2013.

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- [4] Pierangelo Di Sanzo, Francesco Del Re, Diego Rughetti, Bruno Ciciani, and Francesco Quaglia. Regulating concurrency in software transactional memory: An effective model-based approach. In *Proceedings of the 2013 IEEE 7th International Conference on Self-Adaptive and Self-Organizing Systems, SASO '13*, pages 31–40, Washington, DC, USA, 2013. IEEE Computer Society.

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- [9] A. Pellegrini and F. Quaglia, A Study on the Parallelization of Terrain-Covering Ant Robots Simulations , In *Proceedings of the 1st Workshop on Parallel and Distributed Agent-Based Simulations, PADABS - Euro-Par Workshop* , Aachen (Germany), LNCS, Spinger-Verlang, August 2013.
- [10] M. Sadini, A. Barbalace, B. Ravindran and F. Quaglia A Page Coherency Protocol for Popcorn Replicated-kernel Operating System , In *Proceedings of the Many-Core Architecture Research Community Symposium, SPLASH-MARC*, Indianapolis, Indiana, USA, October 2013.
- [11] D. Hendler, A. Naiman, S. Peluso, F. Quaglia, P. Romano, and A. Suissa Exploiting Locality in Lease-Based Replicated Transactional Memory via Task Migration, In *Proceedings of the 7th International Symposium on Distributed Computing, DISC*, Jerusalem, Israel, LNCS, Spinger-Verlang, October 2013.

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- [12] P. Romano, R. Palmieri, F. Quaglia, N. Carvalho and L. Rodrigues, On Speculative Replication of Transactional Systems, *Journal of Computer and System Sciences*, 80(1): 257-276, 2014.
- [13] Pierangelo Di Sanzo, Molfese F. M., Diego Rughetti, and Bruno Ciciani. Providing transaction class-based QoS in in-memory data grids via machine learning. In *Proceedings of the 3rd IEEE Symposium on Network Cloud Computing and Applications*, pages 46–53, New York – USA, February 2014. IEEE Computer Society.

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- [19] Francesco Quaglia, Alessandro Pellegrini and Roberto Vitali Reshuffling PDES Platforms for Multi/Many-core Machines: a Perspective with focus on Load Sharing In *Modeling and Simulation-based Systems Engineering Handbook*, Crc Pr I Llc, 2014, Editors: Daniele Gianni, Andrea D’Ambrogio and Andreas Tolk - To appear
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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:** Mario Caruso, Annalisa Terracina, Claudio Di Ciccio, Marco Angelini, Alessandro Russo.

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:

- *SmartVortex* - October 2010, September 2014 - EU FP7
- *BrIndiSys* - October 2010, June 2013 - Italian AriSLA grant
- *PROMISE* - October 2010, September 2013 - EU FP7 NoE
- *eLF – eLearning Fitness* - January 2011 - March 2014) - EU “Lifelong Learning Programme”

#### Journals

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- [2] Lembo, D., Mecella, M., and Vacca, M. BPM4ED: A research project for designing 21st-century schools. *Bulletin of the IEEE Technical Committee on Learning Technology*, 15:14–17, 2013.
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- [16] Angelini, M., Ferro, N., Santucci, G., and Silvello, G. Visual Interactive Failure Analysis: Supporting Users in Information Retrieval Evaluation In *2013 Italian Information Retrieval workshop*, 61-64
- [17] Angelini, M., Ferro, N., Santucci, G., and Silvello, G. a Visual Analytic Tool for Experimental Evaluation In *2013 21st Italian Symposium on Advanced Database Systems*
- [18] Angelini, M., Santucci, G. Modeling Incremental Visualizations In *2013 EuroVA workshop, Eurovis conference*
- [19] Angelini, M., Ferro, N., Santucci, G., and Silvello, G. Improving Ranking Evaluation Employing Visual Analytics In *2013 Conference and Labs of the Evaluation Forum, CLEF 2013*, 29-40
- [20] Angelini, M., Santucci, G. Modeling Incremental Visual Analytics Visualizations In *2013 IEEE VAST*

### 3.11 Industrial Organization and Management

**Research lines:**

- Competition, Regulation and Industrial Policy
- Economics and management of education and research
- Economics of Network Industries
- Efficiency Analysis
- Industry Studies: Media, 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:** Tiziana D'Alfonso, Anna D'Annunzio, Flavia Di Costa, Giulia Peruzzi.

**PhD Students:** Valentina Bracaglia.

Our research activity includes general issues in industrial economics and management and it is presently focused on the following topics:

*Corporate Sustainability* - Our research focuses on organizational challenges faced by firms to integrate environmental sustainability into their strategies and activities. Specifically, (i) we investigate the role of different types of environmental capabilities (both dynamic and operational capabilities) to improve firm performance; (ii) we analyze the success factors of the green product development process; (iii) we develop tools to characterize and communicate a firm's green products and practices.

*Economics, management and performance of education and research activities* - We developed a particular research experience in the field of: i) evaluation of public policies, including evaluation of higher education institutions, scientific research, technological innovation and their financing; ii) development of new bibliometric approaches and indicators to assess the scientific competitiveness at country, regional and local level; iii) analysis of the characteristics of the market structure of higher education in Italy and in the European countries; iv) analysis of modes of public funding to the university system in Italy and other major European countries. Regarding compulsory education, our research refers to the Equality of Opportunity's theoretical framework and focuses on: i) efficiency, effectiveness and equity of educational system; ii) the implementation of new methodologies in the definition of "types" of students (Latent Class Models and

Multi-Level Latent Class Models); iii) the assessment of physical and monetary resources employed. Finally, an in-depth expertise has been gained in the field of design and evaluation of the administrative activities of the university with particular reference to: i) e-procurement policies and services to support student; ii) the development of systems of funding for students and interventions for students aid; iii) the managerial tools for the management of universities and public research institutions.

*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.

*Innovation management* - Our research focuses the open innovation web-based platforms which allow the collaboration of individuals and companies and the so-called crowdsourcing. We identify 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 analyze 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 models and methodologies for assessing the coherence of companies knowledge strategy to its business strategy and to its competitive and organizational context.

*Methods in Productivity and Efficiency Analysis* - We work on the improvement of the non parametric approach in efficiency analysis including statistical inference (based on the bootstrap), conditional efficiency models, introduction of the heterogeneity and explanation of efficiency differentials. The methods developed are applied to different fields in Economics and Management.

*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.

*Policies, methods and empirical analyses on Government expenditure needs, efficiency and effectiveness of local services* - In recent years, our research has focused also on the following topics : financing, efficiency and effectiveness of local public services; objectives and funding of universal service in railway transport; levels of government and fiscal instruments for the financing of local public transport; development of methods for the determination of the standard cost in local public transport.

*Regulation and competition in the pharmaceutical industry* - The European pharmaceutical industry currently finds itself in a transition phase, where the primary aim of total integration in sales is pursued while maintaining segmentation in regulation. In this framework, we explore the tension between patent protection that is necessary to pre-

serve R&D firms' incentives to innovate, on the one side, and trade liberalization, which is necessary to reach market integration, on the other side.

*Regulation and competition in the telecommunication and media industries* - We study the impact of access regulation and industry structure (vertical integration or separation) on incentives to invest in ultra-broadband access networks. We investigate how bundling affects investment in product quality and design welfare improving price tests for bundled offers that preserve efficiencies from both bundling and quality investment.

*Regulation and competition in the transport industry* - Our research interests focus on air transport (where emphasis is given to some industrial economics aspects such as vertical structure of the industry, network externalities, management and pricing of airport slots, air-rail intermodality), and public local transport (where attention is paid to technological characteristics of public transit systems, to cost structure of private and public local transport operators, to the design of competitive tenders, to standard cost models of different local transport modes such as bus and rail, and to competition-based regulatory methods such as yardstick competition). By combining some theoretical and empirical results with evidence from recent developments, our findings can provide policy makers with remedies to promote static and dynamic efficiency, while fostering, in particular, socially desirable investments in different transport industries.

*Smart cities* - We study smart cities, in terms of their characteristics and dimensions. We analyze performance indicators of smart cities and investigate the relationships among them.

*Social networks analysis* - We study 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.

*Supply chain management* - We carry out exploratory case studies 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 find 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.

### **Projects:**

- *COLLECTIVE - Emerging communities for collective innovation: ICT Operational tool and supporting methodologies for SME Associations* - January 2010, January 2013 - EU FP7.
- *EBRP Project: Assessing the Scientific Performance of Regions and Countries at Disciplinary level by means of Robust Nonparametric Methods: new indicators to measure regional and national Scientific Competitiveness*- 2012-2015 Elsevier.

- *European Tertiary Education Register (ETER)*, Contract No. EAC-2013-038- DG Education, August 2013- July 2015, European Commission.
- *Transatlantic Partnership for Excellence in Engineering (TEE)*, action funded by the European Commission, partership between Sapienza Università di Roma and University of British Columbia, October 2013-october 2014.
- *Airlines - High Speed Rail cooperation and competition*, Research Grant C26N1339HR, Sapienza Università di Roma, September 2013- September 2014

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- [4] 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*, 11(4), 541-568, 2013.
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- [6] 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*, 57, 3-15, 2013.
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- [9] D'Alfonso T., Jiang C., Wan Y., Airport pricing, concession revenues and passenger types, *Journal of Transport Economics and Policy*, 47(1), 71-89, 2013.
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- [12] Iazzolino G., Laise D., Value Added Intellectual Coefficient (VAIC): a methodological and critical review, *Journal of Intellectual Capital*, 14 (4), 547-563 , 2013.
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- [14] Ruocco G., Daraio C., An Empirical Approach to Compare the Performance of Heterogeneous Academic Fields, *Scientometrics* , 97, 601-625, 2013.

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- [15] Agasisti T., Bonomi F., Catalano G., Sibiano P., Un'analisi dell'efficienza delle scuole in Lombardia, in *Rapporto sulla scuola in Lombardia*, Agasisti T., Catalano G., Vittadini G. (Eds.), pp. 241-262, Guerini e Associati, Milano, 2013.
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- [21] Baratta A., Catalano G., Il finanziamento delle residenze universitarie in Italia, in *Gestire le residenze universitarie: aspetti metodologici ed esperienze applicative*, Catalano G. (Ed), pp. 103-114, Il Mulino, Bologna, 2013.
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- [23] Catalano G., Introduzione, in *Gestire le residenze universitarie: aspetti metodologici ed esperienze applicative*, Catalano G. (Ed), pp. 7-20, Il Mulino, Bologna, 2013.
- [24] Catalano G., L'attività fiscale delle università e degli enti di ricerca: una gestione strategica, in *L'inquadrimento fiscale delle università e degli enti di ricerca: vincoli e opportunità*, Catalano G. (Ed), pp. 7-14, Il Mulino, Bologna, 2013.
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- [26] De Toni A.F., Nonino F., Learning objectives and application contexts of business games in management education. in *Business game-based learning in management education*, Baldissin, N., Bettiol, S., Magrin, S., Nonino, F. (Eds.), pp. 25-45, Lulú - TBG Ltd., Udine, 2013.
- [27] Peruzzi G., La spesa sociale in Toscana. Macrotendenze nel triennio 2008/2010 in *AA.VV., Cooperare per l'innovazione sociale. Percorsi di integrazione in Toscana*, Rubbettino Editore, Catanzaro, 2013.

### Books

- [28] Agasisti T., Catalano G., Vittadini G. (Eds.), *Rapporto sulla scuola in Lombardia*, Guerini e Associati, Milano, 2013.
- [29] Baldissin N., Bettiol S., Magrin S., Nonino F. (Eds.), *Business game-based learning in management education*, Lulú - TBG Ltd., Udine, 2013.
- [30] Catalano G. (Ed.), *Gestire le residenze universitarie: aspetti metodologici ed esperienze applicative*, Il Mulino, Bologna, 2013.
- [31] Catalano G. (Ed.), *L'inquadrimento fiscale delle università e degli enti di ricerca: vincoli e opportunità*, Il Mulino, Bologna, 2013.
- [32] Tonchia S., Nonino F., *La Guida del Sole 24 Ore al Project Management. Lo standard internazionale di PM per gestire l'innovazione nei prodotti e nei servizi, le commesse, i progetti di miglioramento*, Il Sole 24 Ore, Milano, 2013.

### Conference proceedings

- [33] Albino V., Berardi U., Dangelico R.M. Smart cities: definitions, dimensions, and performance, *Proceedings of 8th IFKAD 2013*, Zagreb, (Croatia) 12-14 June, 2013.
- [34] Badin L. Daraio C. Simar L., CONDEFF: A Toolbox for Conditional Efficiency Measurement, *Proceedings of the XIII EWEPA Conference*, Helsinki, June, 2013.
- [35] Barbieri G., Catalano G., Peruzzi G., I livelli essenziali delle prestazioni per l'istruzione: proposte per la definizione ed applicazione per la scuola secondaria di I grado secondo l'approccio equality of opportunity, *Atti della XXIV Riunione Scientifica AIIG*, Milano 17-18 ottobre 2013.

- [36] Bonaccorsi A., Daraio C., Simar L., What is the impact of scale and specialization on the research efficiency of European universities?, *Proceedings of ISSI 2013*, J. Gorraiz, E. Schiebel, C. Gumpenberger, M. Hörlesberger and H. Moed (Eds.), Vol. 2, pp. 1817-1829, 2013.
- [37] Bonaccorsi A. Daraio C. Simar L., Economies of scale and scope in European universities: a directional distance approach, *Proceedings of the XXIV RSA AiIG 2013*, Milano, Ottobre, 2013.
- [38] Bongioanni I., Daraio C., Ruocco G., Comparing national disciplinary structures: a quantitative approach, *Proceedings of ISSI 2013*, J. Gorraiz, E. Schiebel, C. Gumpenberger, M. Hörlesberger and H. Moed (Eds.), Vol. 2, pp. 1900-1904, 2013.
- [39] Bongioanni I., Daraio C., Ruocco G., Investigating the distribution of countries' disciplinary profiles, *Book of Abstracts of the 5th Qualitative and Quantitative International Conference*, Rome, Italy: 4-7 June, 2013.
- [40] Catalano G., Erbacci A., The diffusion of a budgeting innovation: spending review in situations of financial emergency, *Atti della XXIV Riunione Scientifica AIIG*, Milano 17-18 ottobre 2013.
- [41] D'Alfonso T., Daraio C., Nastasi A., Assessing the Impact of Competition on the Efficiency of Italian Airports, *Proceedings of the XVII Air Transport Research Society Annual Conference*, Bergamo, Giugno, 2013.
- [42] Dangelico R.M., Pujari D., Green product strategy choices and strategic business unit performance, *Proceedings of the EIASM 20th International Product Development Management Conference*, Paris, France, June 2013.
- [43] Dangelico R.M., Daraio C., Nastasi A., A Systematic Review on the Relationship between Scientific Performance and Competitiveness at Regional Level, *Proceedings of the Technology Transfer Society 2013 Annual Conference*, pp.244-259, Bergamo, November, 2013.
- [44] Daraio C., Consolidating Productivity Stylized facts at the micro level: a General Framework, *Proceedings of the EURO INFORMS MMXIII, 26th European Conference on Operational Research*, Roma, Luglio, 2013.
- [45] Daraio C., Simar L., Choosing the direction for directional distances: new insights, *Proceedings of the XIII EWEPA Conference*, Helsinki, June, 2013.
- [46] Iazzolino G., Laise D., Migliano G., Measures of Value Creation: a comparison between VAIC and EVA, *Proceedings of 8th IFKAD 2013*, Zagreb, (Croatia) 12-14 June, 2013.
- [47] Mauleon E., Cainarca G.C., Daraio C., How effective is the knowledge transfer of a public research organization? First empirical evidence from the Spanish national research council, *Proceedings of ISSI 2013*, J. Gorraiz, E. Schiebel, C. Gumpenberger, M. Hörlesberger and H. Moed (Eds.), Vol. 2, pp. 2004-2007, 2013.

- [48] Vidoli F., Daraio C., Fusco E., Local governments, expenditure needs and level of services: a parametric approximation of nonparametric robust frontier approach, *Proceedings of the EURO INFORMS MMXIII, 26th European Conference on Operational Research*, Roma, Luglio, 2013.
- [49] Zaveri A., JRN Vissoci J.R.N., Daraio C, Pietrobon R., Using Linked Data to Evaluate the Impact of Research and Development in Europe: A Structural Equation Model, *The Semantic Web – ISWC 2013, Lecture Notes in Computer Science*, pp.244-259, Springer Berlin Heidelberg, 2013.

### Submitted papers, technical reports and others

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- [51] Avenali A., Matteucci G., Reverberi P., Broadband investment and welfare under functional and ownership separation, *submitted*, 2013.
- [52] Badin L., Daraio C., Simar L., Explaining Inefficiency in Nonparametric Production Models: the State of the Art, *Annals of Operations Research*, forthcoming, 2013.
- [53] Barbieri G., Catalano G., Peruzzi G., I livelli essenziali delle prestazioni in istruzione: proposte per la definizione ed applicazione per la scuola primaria secondo l'approccio equality of opportunity, *Scuola Democratica*, submitted, 2013.
- [54] Barbot M.C., D'Alfonso T., Sustainable contracts: the case of airports and airlines, *Research in Transportation Economics*, submitted, 2013.
- [55] Bonaccorsi A., Daraio C., Knowledge spillover effects at sub-regional level: Theory and estimation, *Technical Reports Department of Computer, Control, and Management Engineering Antonio Ruberti*, n. 13, 2013.
- [56] Bonaccorsi A., Daraio C. Simar L., Scale and research specialization in European universities: a directional distance approach to teaching efficiency, in *Knowledge, Diversity and Performance in European Higher Education. A changing landscape*, A. Bonaccorsi (Ed.), Edward Elgar Publisher, Cheltenham, forthcoming.
- [57] Bongioanni I. Daraio C. Ruocco G., A Quantitative Measure to Compare the Disciplinary Profiles of Research Systems, *Technical Reports Department of Computer, Control, and Management Engineering Antonio Ruberti*, n. 10, 2013.
- [58] Bracaglia V., D'Alfonso T., Nastasi A., Airports competition in vertically differentiated markets, *Economics of Transportation*, submitted, 2013.
- [59] Catalano G., Erbacci A., How resistance to change affects the implementation of accrual accounting in Italian public universities: a multiple case study, *Financial Accounting and Management*, submitted, 2013.

- [60] Catalano G., Erbacci A., The introduction of accrual accounting in Italian Universities: a technical perspective on networks and isomorphism, *Studies in Higher Education*, submitted, 2013.
- [61] Curi C., Daraio C., Llerena P., What is the productivity change of a university TTOs system at its early stage of development? Evidence from France, *Technical Reports Department of Computer, Control, and Management Engineering Antonio Ruberti*, n. 3, 2013.
- [62] D'Alfonso T., Daraio C., Nastasi A., Assessing the impact of competition on the efficiency of italian airports, *Technical Reports Department of Computer, Control, and Management Engineering Antonio Ruberti*, TR n. 1, 2013.
- [63] D'Alfonso T., Jiang C., Wan Y., Strategic choice of alliance membership under local competition and global networks, *Journal of Transport Economics and Policy*, submitted, 2013.
- [64] D'Alfonso T., Nastasi A., A survey of models of airports-airline interaction, *Transport Reviews*, submitted, 2013.
- [65] Daraio C. Simar L., Directional Distances and their Robust versions. Computational and Testing Issues, *European Journal of Operational Research* , forthcoming, 2013.
- [66] Diana M. Daraio C., A critical review and an integrated set of policy indicators for evaluating the effectiveness of public transport operations, *International Journal of Transport Economics*, forthcoming, 2013.
- [67] Iazzolino G., Laise D., Migliano G., Measuring Value Creation: VAIC and EVA, *Measuring Business Excellence*, forthcoming, 2013.
- [68] Laise D., Marraro L., Iazzolino G., Metachoice for Benchmarking: a case study, *Benchmarking: an international journal*, forthcoming, 2013.
- [69] Mauleon E., Daraio C., Bordons M., Exploring gender differences in patenting in Spain, *Research Evaluation*, forthcoming, 2013.
- [70] Matteucci G., Reverberi P., On some unexpected consequences of parallel trade in pharmaceuticals, *submitted*, 2013.
- [71] Matteucci G., Reverberi P., Parallel trade, product quality, and welfare, *Economics letters*, forthcoming, 2013.

### 3.12 Modeling, Simulation, and Control in Biological and Biomedical Systems

#### Research lines:

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

**Members:** Laura Astolfi, Carlo Bruni (leader ad honorem, retired), Febo Cincotti, Lorenzo Farina, Serenella Salinari (leader).

**PhD Students:** Pietro Aricò, Gianluca Borghini, Federica Conte, Manuela Petti, Elena Previti, Francesca Schettini.

**Post Docs:** Jlenia Toppi.

The research activity in this area concerns with the applications of the general methodologies of modelling, estimation and optimal control theory to the study of biomedical and biological systems. 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, Control and Management Engineering, are working in the above mentioned research lines at different levels of engagement.

In this context, the main research topics are:

- Modelling and Identification of tumor response to radiations;
- Analysis and modeling of insulin secretion and glucose metabolism;
- Estimation of cerebral connectivity in humans by means of structural and functional models and applications;
- Design and validation of devices for Brain Computer Interface based on parameters of the estimated cortical activity;
- Computational optimization in applicative topics of systems biology.

The future activity of the group will focus on the study of the methodologies involved in modelling and estimation of biological/biomedical systems; 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 of stroke subjects; the utilization of the neuroengineering tools in the field of the economy/marketing; the optimization of tumour radiotherapy, 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 "La 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 Biomedical 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, Conway Institute of Biomolecular and Biomedical Research University College, Dublin, Bariatric and Metabolic Surgery, King's College, London.

#### **Projects:**

- *Sistema BCI basato su potenziali stazionari visivi per il controllo pervasivo dell'ambiente per bambini con esiti di paralisi cerebrale infantile*, Progetto di Ateneo 2012.
- *Model of neural circuits subserving attention*, Progetto FARI 2012.
- *Sviluppo di un dispositivo per la misurazione dell'apprendimento in compiti di guida o di controllo di processi mediante l'acquisizione di dati neurometrici tramite EEG*. Progetto FILAS 2013 (Capofila: BrainSigns srl.)
- *Sviluppo e validazione di un'interfaccia cervello-computer per il controllo domotico basata su un paradigma di presentazione rapida e seriale di stimoli visivi*, Progetto di avvio alla ricerca 2012 (responsabile: F. Aloise assegnista di ricerca)
- *Sviluppo di metodi e modelli per l'analisi delle reti funzionali cerebrali nell'uomo, loro descrizione mediante teoria dei grafi e loro caratterizzazione per applicazioni biomediche avanzate*. Finanziamento da IRCCS Fondazione Santa Lucia 2013 per il cofinanziamento di un posto RTD di tipo A (100000 euro).

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### 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:** Domenico Bloisi, Giorgio Grisetti, Luca Iocchi, Daniele Nardi (leader), Giuseppe Oriolo, Alberto Pretto, Marilena Vendittelli.

**PhD Students:** Taigo Maria Bonanni, Roberto Capobianco, Martina Deturres, Maurilio Di Cicco, Ricardo Dodds, Guglielmo Gemignani, Thien Nguyen-Duc, Andrea Pennisi, Fabio Previtali, Jacopo Serafin.

**Post Docs:** Gabriele Randelli, Paolo Stegagno.

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 implementation of systems 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 and multi-robot systems in soccer, search and rescue, surveillance and domotics. Specifically, the problem of sensor fusion and situation awareness has been targeted in the framework of maritime surveillance.

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. The following is a list of relevant activities by the members of the group:

- Luca Iocchi has been member of RoboCup@Home Executive and Trustee Committees and co-organizer of RoboCupHome 2013.
- Daniele Nardi has been President of the RoboCup Federation, 2013.
- Daniele Nardi has been chair of the Robotics Track of the Autonomous Agents and Multi-Agent Systems, 2013.
- The SPQR team of humanoid soccer players obtained the 1st place in Iranian Open, the 3rd place in German Open, Magdeburg, and participated in RoboCup 2013, Eindhoven, 2013.

#### Projects:

- *BEESAFE* - December 2011, December 2013 - Sistemi Software Integrati - Daniele Nardi, Luca Iocchi.
- *Smart Monitoring of Complex Public Scenes* - May 2011, April 2013 - Dept. of Homeland Security (DHS), USA - Daniele Nardi, Luca Iocchi.
- *Jump traffic Jam (JTJ)* - October 2013, December 2014 - Duel TV - Daniele Nardi, Luca Iocchi.
- *ROVINA* - February 2013, January 2016 - CEE, FP7 - Giorgio Grisetti, Daniele Nardi.
- *RoCKIn* - January 2013, December 2015 - Coordination Action CEE, FP7 - Daniele Nardi, 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 (retired), Francesco Delli Priscoli (leader), Claudio De Persis, Alessandro Di Giorgio, Antonio Pietrabissa.

**PhD Students:** Giorgia Chini, Andrea Lanna, Francesco Liberati, Andi Palo, Martina Panfili, Letterio Zuccaro.

**Post Docs:** Silvia Canale, Andrea Fiaschetti, Donato Macone, Andrea Mercurio, Silvano Mignanti, Guido Oddi, Vincenzo Suraci.

The networked systems area has developed, in the last 13 years, thanks to the successful participation in 35 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:

- *Cockpit-CI, Cybersecurity on SCADA: risk prediction, analysis and reaction tools for Critical Infrastructures* (managed by CRAT) - April 2012, March 2015 - EU SEC FP7 Project.
- *DAAS, Data Analysis and Acquisition System* - November 2013, March 2015 - Progetto FILAS.Co-research
- *DLC+VIT4IP, Distribution Line Carrier: Verification, Integration and Test of PLC Technologies and IP Communication for Utilities* - January 2010, April 2013 - EU FP7 ICT-ENERGY
- *Fi-WARE, Future Internet Core Platform* - May 2011, April 2014 - EU ICT FP7 Project.
- *MOBINCITY, Smart Mobility in Smart City* (managed by CRAT) - July 2012, June 2015 - EU FP7 ICT Project
- *nSHIELD, New embedded System architecture for multi-Layer Dependable solutions* - September 2011, August 2014 - EU ARTEMIS-JU Project
- *PLATINO* - July 2012, June 2015 - Progetto MIUR PON.
- *SMARTV2G, Smart Vehicle to Grid Interface* - June 2011, May 2014 - EU FP7-2011-ICT-GC Project
- *SWIPE, Space Wireless sensor networks for Planetary Exploration* (managed by CRAT) - April 2013, October 2015 - EU SPA FP7 Project.
- *TASS, Total Airport Security System* - April 2010, March 2014 - EU FP7-2011-ICT-GC Project.

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- [17] De Persis C., Sailer R., Wirth F., On inter-sampling times for event-triggered large-scale linear systems, *Proceedings 52nd IEEE Conference on Decision and Control, CDC 2013*, 5301–5306, Florence, Italy, December 10-13, 2013.
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- [34] Oddi G., Reinforcement Learning and Cooperative Receding Horizon approaches for the routing problem, Tesi di dottorato in Ingegneria dei Sistemi, XXV ciclo, Marzo 2013.

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

**PhD Students:** Raffaello Bonghi, Giovanni Mattei.

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.

The notion of incremental generalized homogeneity has been recently introduced in the design of nonlinear stabilizing controllers. 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, data acquisition and fusion.

The applicative aspects of the research activities are carried out at the Systems 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,

- *Visual inspection of a TOKAMAK machine* - 2012, ENEA Project.

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- [13] Placidi G., Avola D., Iacoviello D., Cinque L. Overall design and implementation of the virtual bloke. *Computers in Biology and Medicine*, vol. 43, pp. 1927-1940, 2013.
- [14] Paris S., Mary D., and A. Ferrari A. Detection tests using sparse models, with application to hyperspectral data. *IEEE Transactions on Signal Processing*, Vol. 61, n. 6, pp. 1481-1494, 2013.

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- [22] C. De Persis, R. Sailer, F. Wirth. On inter-sampling times for event-triggered large-scale linear systems. In *Proceedings 52nd IEEE Conference on Decision and Control, CDC 2013*, pp. 5301-5306, Florence, Italy, December, 2013.
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- [29] Pucci, D., L.Marchetti, and P. Morin. Nonlinear Control of Unicycle-like Robots for Person Following. In *Proceedings IEEE International Conf. on Intelligent Robots and Systems (IROS)*, 2013.

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- [31] Pucci D. Towards a unified approach to the control of aerial vehicles. Dottorato in Ingegneria dei Sistemi XXV Ciclo, 2013
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- [33] Andreaus U., Colloca M., Iacoviello D. Optimal bone density distributions: numerical analysis of the osteocyte spatial influence in bone remodeling, To appear in *Computer Methods and Programs in Biomedicine*, 2014
- [34] Cafaro B., Canale S., De Santis A., Iacoviello D., Pirri F. Segmentation based pattern recognition for peri-urban areas in X-band SAR images”, To appear in *Lecture Notes in Computational Vision and Biomechanics*, SPRINGER book series, IN PRESS
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- [36] Canale S., D'Orsi L., Iacoviello D. A texture based pattern recognition of tissues in microscopic liver images, submitted
- [37] Di Cocco V., Iacoviello D., Iacoviello F., Rossi A., Fatigue loading of a ferritic ductile cast iron: damaging characterization To appear in *Lecture Notes in Computational Vision and Biomechanics* SPRINGER book series, IN PRESS
- [38] Di Cocco v., Iacoviello F., Rossi A., Iacoviello D. Macro and microscopical approach to the damaging micromechanisms analysis in a ferritic ductile cast iron. To appear in *Theoretical and applied fracture mechanics*, 2014.
- [39] De Persis C., Jensen T.N., Ortega R., and Wisniewski R., Output regulation of large-scale hydraulic networks. To appear in *IEEE Transactions on Control Systems Technology*, 2014.
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### 3.16 Innovation, Internationalization and Environment

#### Research lines:

- R&D and Innovation
- Internationalization and the Environment
- Coalition Formation Models and Collusive Agreements in Oligopolies
- The Governance of Nonprofit Organizations

**Members:** Marco Antonio Marini, Giorgio Rodano (retired), Francesca Sanna–Randaccio (leader), Roberta Sestini.

**Post Doc:** Chiara Conti (since November 2013).

This group has recently investigated the theoretical explanations and empirical implications of some interrelated phenomena, namely, technological innovation -with a particular emphasis on R&D agreements -, strategic behavior of Multinational Enterprises (MNEs) in R&D intensive industries, environmental and foreign direct investment (FDI) policies, coalition formation in oligopolies. These research topics combine two strands of research previously followed by some 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' international strategy choices following a game-theoretic approach.

These streams of research have converged, producing in the more recent years a series of results concerning firms' innovative performance, their international expansion via foreign direct investment (FDI), paying attention to the effects of climate policies on firms' decision to relocate production abroad, 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:

**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, analyzing 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 out in this area incorporates the hypothesis of firms' heterogeneity due to different emissions technologies.

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 channelling 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 relevant factors in determining the probability to have a foreign supplier of technology in the project.

**The Governance of Nonprofit Organizations** We developed 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 analyzed 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.

**R&D spillovers, Asymmetric Information and the Incentive to Cooperate in Research Activities** The role of R&D cooperation agreements in a context of asymmetric information about firms' R&D productivity is investigated. Moreover, assuming that the R&D formation process is endogenous makes it possible to analyze the incentive to engage in R&D cooperation, thus going further a simple comparison between *regimes*. It turns out that, when firms compete in R&D, the presence of asymmetric information can worsen the under-investment problem. However, a signaling role of cooperation agreements emerges, leading to welfare improvement. This research line also contributes to explain the empirical evidence on R&D features.

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- [10] Marconi, D. and Sanna-Randaccio, F. The Clean Development Mechanism and Technology Transfer to China. In Verbeke, A., van Tulder, R. and Strange, R. (eds), *International Business and Sustainable Development*, Bingley, UK. Emerald Group Publishing Limited, 351-390, 2013.

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- [15] Kopel M. and Marini, M. A. Strategic Delegation in Mixed Oligopoly with Consumer Cooperatives. EMS Working Papers 1306, University of Urbino, Italy, 2013.
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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:** Marco Cognetti, Claudio Gaz, Emanuele Magrini, Valerio Modugno, Antonio Paolillo.

**Post Docs:** Massimo Cefalo, Fabrizio Flacco, Lorenzo Rosa.

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; control of manipulators with flexible elements (in particular, with Variable Stiffness Actuation); hybrid force/velocity and impedance control of manipulators interacting with the environment; optimization schemes in kinematically redundant robots; motion planning for high-dimensional systems; motion planning and control of wheeled mobile robots and other nonholonomic mechanical systems; control-based motion planning for mobile manipulators; motion planning and control of locomotion in humanoid robots; stabilization of underactuated robots; control of locomotion platforms for VR immersion; sensor-based navigation and exploration in unknown environments; image-based visual servoing; control and visual servoing for unmanned aerial vehicles (UAV); multi-robot coordination and mutual localization; unsupervised continuous calibration of mobile robots; actuator/sensor fault detection and isolation in robots; safe control of physical human-robot interaction; 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.

Most research activities undergo experimental validation in our Robotics Laboratory, that currently provides two articulated manipulators (a 7R lightweight KUKA LBR4+ with FastResearchInterface, a 6R KUKA KR5 industrial robot), an underactuated system

(Pendubot by Quanser), and several mobile robots, including wheeled (a MagellanPro by iRobot, a team of five Kheperas III by K-Team), legged (a NAO humanoid robot by Aldebaran, 2 quadruped Sony AIBOs), and flying (a Hummingbird and a Pelican quadrotor UAVs by AscTec) platforms. 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.

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- [5] Cefalo M., Oriolo G., and Vendittelli M., Planning safe cyclic motions under repetitive task constraints. *Proc. 2013 IEEE International Conference on Robotics and Automation*, Karlsruhe, DEU, pp. 3792–3797, 2013.
- [6] Cefalo M., Oriolo G., and Vendittelli M., Task-constrained motion planning with moving obstacles. *Proc. 2013 IEEE IEEE/RSJ International Conference on Intelligent Robots and Systems*, Tokyo, JPN, p. 5758–5763, 2013.

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- [13] Oriolo G., Paolillo A., Rosa L., and Vendittelli M., Vision-based trajectory control for humanoid navigation. *Proc. 13th IEEE-RAS International Conference on Humanoid Robots*, Atlanta, USA, p. 118–123, 2013.
- [14] Shariari N., Fantasia S., Flacco F., and Oriolo G., Robotic visual servoing of moving targets. *Proc. 2013 IEEE IEEE/RSJ International Conference on Intelligent Robots and Systems*, Tokyo, JPN, p. 77–82, 2013.
- [15] Stegagno P., Cognetti M., Rosa L., Peliti P., and Oriolo G., Relative localization and identification in a heterogeneous multi-robot system. *Proc. 2013 IEEE International Conference on Robotics and Automation*, Karlsruhe, DEU, pp. 1849–1856, 2013.

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### 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:** Aris Anagnostopoulos, Luca Becchetti, Stefano Leonardi (leader).

**PhD Students:** Marek Adamczyk, Noor Aldeen Alawad, Reem Atassi, Riccardo Colini Baldeschi, Adriano Fazzino, Ida Mele.

**Post Docs:** Diodato Ferraioli, Bart de Keijzer

Our interest lies on algorithmic and game-theoretic methods for characterizing the structure of large-scale complex networks with application including 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, and on the design of auction mechanisms that induce desired behaviors by users in network settings.

In a series of works we studied some resource management problems in which the goal is to make decisions in a way that we optimize the use of available resources. Along this high-level goal, we studied some online variants of the knapsack problem, a classic problem in combinatorial optimization in which the goal is to select a subset of items so as to maximize profit while satisfying some weight constraints. Our study took into account randomization, additional knapsacks, removals of previously accepted items, and dependency of the items profits on their sizes. We determined when a subset of those is sufficient and necessary to obtain constant competitive ratio, getting tight bounds in some cases. In case of multiple knapsacks, we studied two objectives: the sum and the maximum of profits over all knapsacks, both of which were considered before in more restricted settings. We also continued our study of algorithms for structured networks. In particular, we studied the complexity of the Steiner tree problem, and we discovered the first subexponential-time parameterized algorithm for this problem on planar graphs. Another problem, the problem of unsplittable flow on a path is a special case of a flow problem, which can be seen as a scheduling problem. We provided approximation algorithms improving past results. Finally, we have proposed and analyzed simple algorithms to perform recommendations in fully decentralized, mobile scenarios.

We also considered the following game-theoretic problem arising in speed-scaling scheduling. Agents submit their jobs to a server, declaring the jobs' parameters and importance of timely completion. The server processes all the jobs in a way that observes

the users' preferences by adjusting processing speed, which results in a certain energy cost, where the power is a convex function of speed. This energy is charged to the agents through a mechanism. We design a (non-truthful) mechanism that guarantees existence of pure Nash equilibria and approximate budget balance for well-behaved power functions.

In the *stochastic probing model* an element in a universe (e.g., an edge in a graph) exists with some probability, and we can find if the element exists only if we probe the item. The goal is to solve a problem with the minimum number of probes. An important problem that falls under the framework of stochastic probing is Sequential Posted Pricing. We provide 2-approximation for SPM in single matroid environments using only linear programming, but with a novel rounding procedure, which is well suited for stochastic problems. We also studied online stochastic variants of the set cover problem, one of the most fundamental problems in optimization with a variety of applications.

A large amount of our research is on game-theoretic aspects of computation. We have designed auction and pricing mechanisms that are able to allocate goods to individuals in an optimal way. We construct prior-free auctions with constant-factor approximation guarantees with ordered bidders, in both unlimited and limited supply settings. Our auctions are simultaneously near-optimal in a wide range of Bayesian multi-unit environments. In addition, studied games in which players are not only interested for their own utility, but they may be altruistic or spiteful, showing that in some games corresponding to realistic settings the social outcome might worsen as players become more altruistic.

Finally, a new promising computational model uses biological organisms for performing computations and our group is exploring its potential. We have analyzed a discrete version of a natural algorithm for shortest path computation, inspired by the behaviour of the well-known *Physarum* slime mold.

### Projects:

- *MULTIPLEX: Foundational Research on MULTILEVEL COMPLEX networks and systems*, 2012–2015, EU FET, FP7.
- PAAI: Practical Approximation Algorithms, 2010–2014, Associate partner at ERC Starting Grant, FP7.
- FOC: Forecasting Financial Crises, 2010–2013, EU ICT, FP7.
- FOC: Forecasting Financial Crises, 2010–2013, EU ICT, FP7.
- Google research award (winner: Stefano Leonardi), awarded in 2012, running.

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