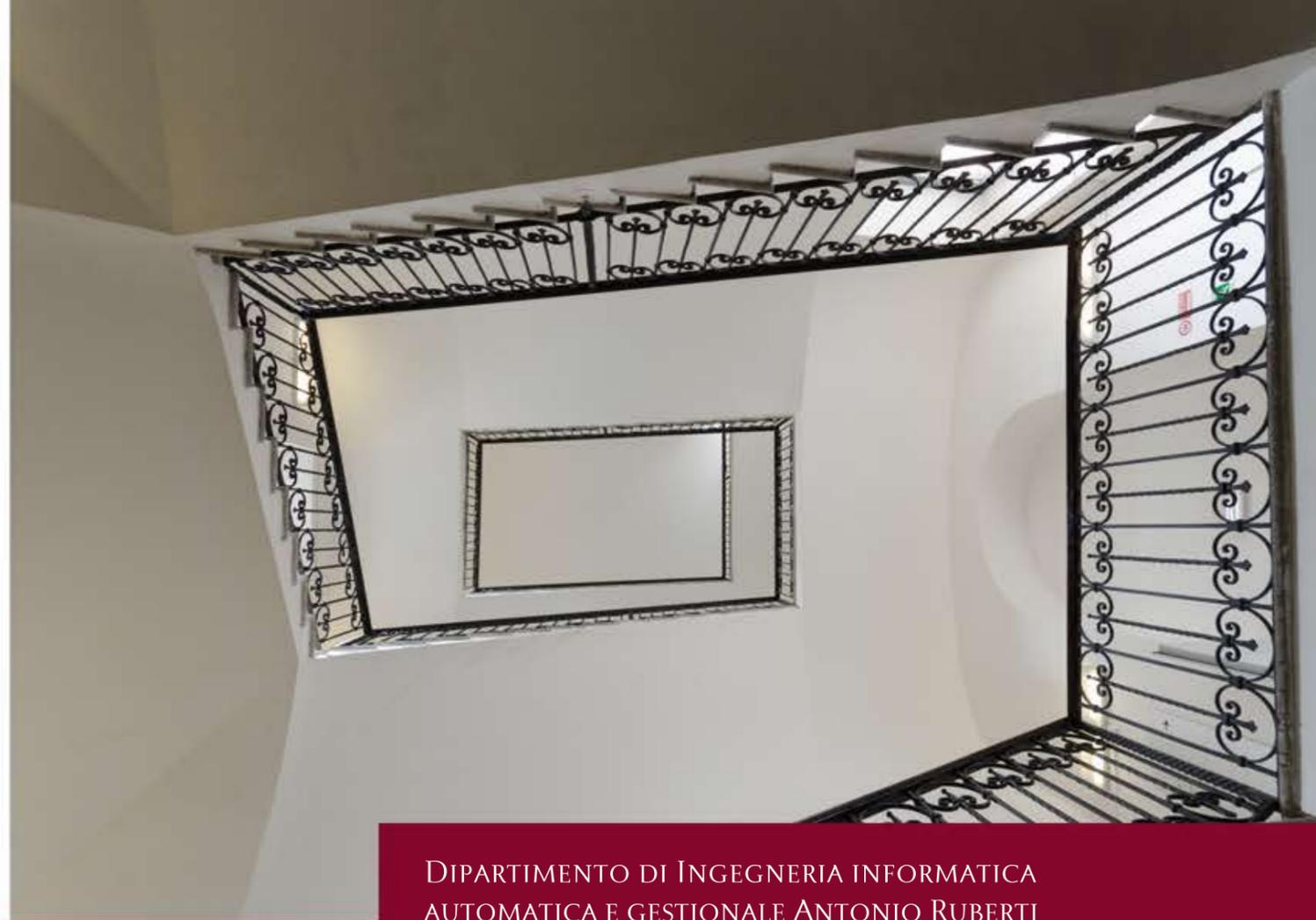


DIAG - Research areas

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

Research report 2012



DIPARTIMENTO DI INGEGNERIA INFORMATICA
AUTOMATICA E GESTIONALE ANTONIO RUBERTI



SAPIENZA
UNIVERSITÀ DI ROMA

Research report 2012

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

Research report 2012

Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti

Sapienza Università di Roma

Via Ariosto 25

00185 Roma

Italia

T +39 06 77274140

F +39 06 77274129

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

Cura e composizione: Renato BRUNI
Claudio LEPORELLI
Grafica di copertina: Anna Paola DI RISIO
I edizione: Maggio 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 2012.

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 2012 consists of 24 full professors, 23 associate professors, and 28 assistant professors (*ricercatori*). They provide education at the undergraduate and graduate levels to several programs of the two schools of engineering at Sapienza (*facoltà di Ingegneria dell'informazione, informatica e statistica* and *facoltà di Ingegneria civile ed industriale*), with main responsibility in the curricula in informatics, systems and control, and engineering management. Teaching activities are not illustrated in this report; a description may be found at <http://www.dis.uniroma1.it> under the entry "Teaching".

Furthermore, DIAG offers two PhD programs, and cooperates with other two PhD programs offered by other departments. 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 description of their main research lines, together with the list of people involved, and the collection of publications appeared in 2012.

2 General Information

2.1 Location

The location of DIAG is the building known as “Scuola Silvio Pellico”, in Via Ariosto 25, Rome. DIAG is on the web at <http://www.dis.uniroma1.it>.

2.2 Facilities

Library

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

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

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.dis.uniroma1.it/~alcor>

Head: Fiora PIRRI

Algorithms Engineering Laboratory

Via Ariosto 25 - wing B1

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

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

Head: Camil DEMETRESCU

Automation Laboratory

Via Ariosto 25 - basement

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

Head: Claudio GORI GIORGI

BiBiLab - Bioengineering and Bioinformatics Laboratory

Via Ariosto 25 - basement

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

Head: Serenella SALINARI

DAMSO Laboratory

Via Ariosto 25 - basement

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

Head: Alberto DE SANTIS

Data And Service Integration Laboratory (DASILab)

Via Ariosto 25 - room 213, wing B2

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

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

Head: Maurizio LENZERINI

Organization: Massimo MECELLA

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.dis.uniroma1.it/~labsec>

Head: Roberto BALDONI

Management Engineering Laboratory

Via Ariosto 25 - room A122 and A123, wing A1

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

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

Head: Massimo ROMA

Middleware Laboratory - MIDLAB

Via Ariosto 25 - wing B1

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

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

Head: Roberto BALDONI

Network Control Laboratory

Via Ariosto 25 - room 215, wing A2

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

Web: <http://labreti.ing.uniroma1.it/>

Head: Francesco DELLI PRISCOLI

Robotics Laboratory

Via Ariosto 25 - basement

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

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

Head: Giuseppe ORIOLO

ROCOCO - Robot COgnitivi COoperanti

Via Ariosto 25 - basement

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

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

Head: Daniele NARDI

Systems and Control Laboratory

Via Ariosto 25 - basement

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

Web: http://labsis.dis.uniroma1.it/LSW_R2/

Head: Salvatore MONACO

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.dis.uniroma1.it/>.

Educational Laboratories

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

Computer Science Laboratory Paolo Ercoli for introductory courses

Via Tiburtina 205, Roma.

About 150 stations are available for undergraduate teaching.

Person in charge: Umberto NANNI.

PC and Workstations Laboratory Paolo Ercoli for advanced courses

Via Eudossiana 18, Roma.

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

Person in charge: Umberto NANNI.

Management Engineering Laboratory

Via Ariosto 25 - room A122 and A123, wing A1

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

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

Person in charge: Massimo ROMA

Software Development (Thesis Students) Laboratory

via Ariosto 25 - rooms A1 and A2

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

Person in charge: Massimo MECELLA

2.3 People

Head of Department Claudio LEPORELLI

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 (up to October 2012)
Francisco FACCHINEI
Claudio GORI GIORGI
Luigi GRIPPO (up to October 2012)
Alberto ISIDORI (up to October 2012)
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 SCHAERF

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 from February 2012)
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 (from April 2012)
Laura ASTOLFI (from July 2012)
Luca BECCHETTI
Roberto BERALDI
Domenico Daniele BLOISI (from Sept. 2012)
Silvia BONOMI
Renato BRUNI
Claudia CALIFANO
Febo CINCOTTI
Rosa Maria DANGELICO
Claudio DE PERSIS
Paolo DI GIAMBERARDINO
Alessandro DI GIORGIO
Marco FRATARCANGELI
Giorgio GRISETTI
Daniela IACOVIELLO
Domenico LEMBO
Giorgio MATTEUCCI
Massimo MECELLA
Carlo Maria MEDAGLIA
Fabio NONINO
Fabio PATRIZI
Antonio PIETRABISSA
Antonella POGGI (up to November 2012)
Leonardo QUERZONI
Roberta SESTINI
Stravros VASSOS (from September 2012)
Marilena VENDITTELLI
Andrea VITALETTI

Post Doc research associates (assegnisti di ricerca)

Maria Cristina ARCURI
 Fabio ALOISE
 Emanuele BASTIANELLI
 Massimo CEFALO
 Fabrizio COSSU
 Fabrizio FLACCO
 Vincenzo FORTE
 Mario GIANNI
 Ettore IACOMUSSI
 Lukasz JEZ
 Lorenzo LAMPARIELLO
 Mariano LEVA
 Riccardo MANCINI
 Silvano MIGNANTI
 Gabriele RANDELLI
 Marco RUZZI
 Arnab SINHA
 Paolo STEGAGNO

Research assistants

Bruno CAFARO
 Silvia CANALE
 Gionata CERASUOLO
 Cristina CIVILI
 Ugo Maria COLESANTI
 Fabio D'ANDREAGIOVANNI
 Marianna DE SANTIS
 Pierangelo DI SANZO
 Fabrizio GRANDONI
 Andrea LANNA
 Luigi LAURA
 Domenico MACONE
 Donato MACONE
 Pasquale MANDATO
 Silvano MIGNANTI
 Roberto PALMIERI
 Vincenzo PASCALE
 Panagiotis PAPADAKIS
 Alessandro PELLEGRINI

Giulia PERUZZI
 Mauro PIACENTINI
 Valentina POLLI
 Andrea RIBICHINI
 Diego RUGHETTI
 Valerio SANTARELLI
 Vincenzo SURACI
 Gabriele TAMEA
 Paolo TERREVOLI
 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 (from February 2012)
 Anna Paola DI RISIO
 Andrea DORI
 Giuseppe FILACI
 Marcello FIORINI (from February 2012)
 Marco GIULIANI
 Luciano GRANDI (from February 2012)
 Marcello PANI
 Tiziana TONI

Auxiliary services

Antonio SIMEONI

Library

Laura ARMIERO
 Roberta PROIETTI SEMPRONI

2.4 Doctoral Programs

DIAG directly hosts the PhD programs in *Engineering in Computer Science* and in *Systems Science 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, and in *Economics and Management of Technology* hosted by the Department of Management Engineering of the University of Bergamo.

Bioengineering

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

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

PhD students (working at DIAG)

| <u>XXV course</u> | <u>XXVI course</u> | <u>XXVIII course</u> |
|-------------------|-------------------------------------|----------------------|
| Jlenia TOPPI | Pietro ARICÒ Francesca SCHETTINI | Elena PREVITI |

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

| XXIV course | XXV course | XXVI course |
|---|---|---|
| Lorenzo BERGAMINI Domenico Fabio SAVO | Adriano CEROCCHI Riccardo DE MASELLIS Claudio DI CICCIO Ricardo DODDS Paolo FELLI Donatella FIRMANI Mario GIANNI Andrea MARRELLA Ida MELE Luca MONTANARI Hani QUSA Roberto VITALI | Leonardo ANIELLO Floriana DI PINTO Francesco LEOTTA Khalil M.H. AL MASSRI Alessandro PELLEGRINI Sebastiano PELUSO Diego RUGHETTI Alessandro RUSSO Suzanne VAN DE STER |
| XXVII course | XXVIII course | |
| Giuseppe Antonio DI LUNA Bruno CAFARO Mario CARUSO Cristina CIVILI Riccardo COLINI BALDESCHI Nguyen DUC THIEN Francesco FICAROLA Andrea PENNISI Valerio SANTARELLI Erfan SHOJAEI BARJUEI | Nadine ABU RUMMAN Marek ADAMCZYK Noor ALDEEN KAMEL Marco ANGELINI Reem ATASSI Taigo Maria BONANNI Daniele CONO D'ELIA Marco CONSOLE Angela DI IORIO Adriano FAZZONE Giulia FISCON Guglielmo GEMIGNANI Lorenzo LEPORE Maryam MOUSAVI IRAEI Valsamis NTOUSKOS Fabio PETRONI Fabio PREVITALI | |

PhD theses completed in 2012

Pierangelo DI SANZO
Performance Models of Concurrency Control Protocols for Transaction Processing Systems
 Advisor: Bruno CICIANI
 March 2012

Luca FILIPPONI
From Wireless Sensor Networks towards People centric sensing
 Advisor: Andrea VITALETTI
 March 2012

Letizia MARCHEGIANI

Top-Down Attention Modelling in a Cocktail Party Scenario

Advisor: Fiora PIRRI

March 2012

Roberto PALMIERI

Speculative Protocols for Actively Replicated Transactional Systems

Advisor: Francesco QUAGLIA

March 2012

Matia PIZZOLI

Visual Saliency in the Wild: Moving the Analysis of Gaze Behaviors to Three-Dimensional, Unstructured Environments

Advisor: Fiora PIRRI

March 2012

Marco PLATANIA

Ordering, Timeliness and Reliability for Publish/Subscribe Systems over WAN

Advisor: Roberto BALDONI

March 2012

Economics and Management of Technology

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

PhD students (working at DIAG)

XXV course

Tiziana D'ALFONSO

Systems Engineering and Operations Research

The council of professors of the PhD program in Systems Engineering 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: Systems Engineering 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, intelligent 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)

| <u>XXV course</u> | <u>XXVI course</u> | <u>XXVII course</u> |
|----------------------------|----------------------------|----------------------------|
| <i>Systems Engineering</i> | <i>Systems Engineering</i> | <i>Systems Engineering</i> |
| Andrea ABELLI | Giorgia CHINI | Francesco LIBERATI |
| Andrea FIASCHETTI | Andi PALO | Giovanni MATTEI |
| Guido ODDI | Martina PANFILI | Antonio PAOLILLO |
| Daniele PUCCI | Silvia PARIS | Raffaele RUINI |
| | Margherita PETROCCHI | Letterio ZUCCARO |
| | Lorenzo ROSA | |
| <i>Operations Research</i> | | <i>Operations Research</i> |
| Gianpiero BIANCHI | | Andrea MANNO |
| Andrea IANNI | <i>Operations Research</i> | Olimpia OTTAVIANI |
| Vittorio LATORRE | Alessandra REALE | |
| Simone SAGRATELLA | | |
| | <u>XXVIII course</u> | |
| | <i>Systems Engineering</i> | |
| | Raffaello BONGHI | |
| | Federica CONTE | |
| | Marco COGNETTI | |
| | Claudio Roberto GAZ | |
| | Andrea LANNA | |
| | Emanuele MAGRINI | |
| | Andrea SIMEONI | |
| | Marsilio TURATTI | |
| | <i>Operations Research</i> | |
| | Jahanbani ADEL | |
| | Valentina BRACAGLIA | |
| | Umberto DELLE PIANE | |
| | Daniele FERONE | |
| | Stefania RENZI | |

PhD theses completed in 2012

Operations research

Carla MICHINI

The Stable Set Problem: Some Structural Properties and Relaxations

Advisor: Antonio SASSANO

June 2012

Marianna DE SANTIS

Continuous Approaches to MIP Problems

Advisor: Stefano LUCIDI

June 2012

Mauro PIACENTINI

Nonlinear formulation of Semidefinite Programming and Eigenvalue Optimization

Advisor: Laura PALAGI

June 2012

Systems Engineering

Federico PAPA

Optimal solution for a cancer radiotherapy problem

Advisor: Carlo BRUNI

March 2012

Fabrizio FLACCO

Modeling and Control of Robots with Compliant Actuation

Advisor: Alessandro DE LUCA

March 2012

Laura FOGLIATI

A Reinforcement Learning Based Cognitive Approach for Quality of Experience Management in the Future Internet Architecture

Advisor: Francesco DELLI PRISCOLI

March 2012

Lorenzo LAMPARIELLO

Penalty Methods for the Solution of Generalized Nash Equilibrium Problems and Hemivariational Inequalities with Constraints

Advisor: Luigi GRIPPO

March 2012

Paolo STEGAGNO

Mutual Localization from Anonymous Measures in Multi-Robot Systems

Advisor: Giuseppe ORIOLO

March 2012

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 2012.

Gregorio CONVERTINO, Xerox Research Center Europe, Grenoble, France, June-September 2012

Javier David Fernández GARCÍA, University of Valladolid, Spain, September-November 2012

Behzad GOLSHAN, Boston University, June-July 2012

Anupam GUPTA, Carnegie Mellon University, February 2012

Aida HUERTA, Department of Operations Research, National Autonomous University of Mexico, UNAM, Mexico, October 2012 - April 2013

Andreas KARWARTH, University of Freiburg, Germany, March-May 2012

Stephen KIMANI, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya, March-June 2012

Elias KOUTSOPIAS, Oxford University, April-June 2012

Yves LESPERANCE, York University, Toronto, Ontario Canada, June-September 2012

Matteo RIONDATO, Brown University, June-July 2012

Léopold SIMAR, Université catholique de Louvain, Belgium, March-May 2012

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 2012, in chronological order. Also the Workshops organized at DIAG are reported, with the exception of the project meetings.

- February 20, Philippe Fraisse, LIRMM, Université Montpellier 2, *Robotics and Neuro-Rehabilitation: Modeling and Control*.
- February 21, Anupam Gupta, Carnegie Mellon University, U.S.A., *Approximation Algorithms for Stochastic Combinatorial Optimization*.
- February 27, Fosca Giannotti, Istituto di Scienza e Tecnologie dell'Informazione - CNR - Pisa, *Mining the patterns and profiles of human mobility*.
- March 30, Kazuya Yoshida, Graduate School of Engineering, Tohoku University, *Mobile Robots for Exploration of Extreme and Uncertain Environments in Terrestrial and Planetary Applications*.
- April 18, Ian Leslie, University of Cambridge Computer Laboratory, *New Life for Sensor Networks: The Window of Opportunity of Lighting Retrofit*.
- April 19, Elias Koutsoupias, University of Athens, *Seminar series on Algorithmic Game Theory and Mechanism Design*.
- April 26, Cristina Rossi Lamastra, Politecnico di Milano, *University specialization and new firm creation: evidence from the Italian case*.
- May 18, Prof. Sergio Currarini, Università Cà Foscari di Venezia, *Risky Behaviour in Social Networks: Externalities, Altruism and Peer Effects*.
- May 25, Christoph Buchheim, TU Dortmund, *Dual Bounds from Nonconvex Relaxations of Discrete Quadratic Optimization Problems*.
- May 25, Francisco Facchinei, DIAG, "Sapienza" University of Rome, *Distributed algorithms for the solution of (generalized) Nash equilibrium problems*.
- May 30, Leonid Libkin, LFCS - University of Edinburgh, *Approximation of conjunctive queries*.
- June 19, Nicolai Petkov, University of Groningen, *Brain-inspired computing for machine vision*.
- June 21, Jorge Angeles, Dept. of Mechanical Engineering, McGill University Montreal CANADA, *Robot-aided Rapid Prototyping of Ice Structures*.
- June 28, Andrea Bajo, Advanced Robotics and Mechanism Applications (ARMA) Laboratory Dept. of Mechanical Engineering, Vanderbilt University, Nashville, TN, USA, *Algorithms for Control, Collision Detection, and Estimation of Contact Location of Multi-Backbone Surgical Continuum Robots*.
- July 2, Oussama Khatib, Artificial Intelligence Laboratory, Computer Science Department, Stanford University, CA, USA, *Robots and the human*.
- July 26, Luca Marchionni, Pal Robotics, Barcelona, Spain, *Pal Robotics Robots*.

- September 19, Henk F. Moed, Centre for Science and Technology Studies (CWTS), Leiden University, the Netherlands, *Potentialities of integrating various data sources in bibliometric research.*
- September 19, Andrea Bonaccorsi, University of Pisa, Italy, *Economies of scale and scope in European universities.*
- September 24, Maria Domenica Di Benedetto, University of L'Aquila, Italy, *Model matching: From nonlinear to hybrid systems.*
- September 24, Alessandro Astolfi, Imperial College London, UK, and University of Roma Tor Vergata, Italy, *Model reduction by moment matching for nonlinear systems.*
- September 24, Lorenzo Marconi, University of Bologna, Italy, *Steady state and internal model principle for hybrid systems.*
- September 24, Andrea Serrani, Ohio State University, USA, *The role of zero dynamics in aerospace systems: A case study in control of hypersonic vehicles.*
- September 24, Claudio De Persis, University of Groningen, the Netherlands, and Sapienza University of Roma, Italy, *Detection and isolation of faults and attacks.*
- September 24, Alberto Isidori, Sapienza University of Roma, Italy, *Lecture.*
- September 26, Claudia Loebbecke, University of Cologne, *An IT Trend Reshuffling the Economics and Strategies of the Book Industry.*
- October 2, Nitin Yadav and Sebastian Sardina, School of Computer Science and IT, Royal Melbourne Institute of Technology, *Qualitative Approximate Behavior Composition.*
- October 15, Gary Bradski, OpenCV Foundation and Founder and CTO at Industrial Perception, *Opensource Computer Vision and Robotics.*
- October 22, Kevin Leyton-Brown, University of British Columbia, *Seminar Series on Competition and Cooperation in Multiagent Systems.*
- November 5, Benedetto Lepori, Director of the Centre for Organisational Research, Faculty of Economics, University of Lugano, *Competition for talent. Country and university-level effects in the internationalization of European universities.*
- November 8, Luca Becchetti, DIAG, "Sapienza" University of Rome, *Combinatorial optimization in Web search and data mining.*
- November 14, Abderrahmane Kheddar, CNRS-AIST Joint Robotics Laboratory, Tsukuba, Japan, *Contact Humanoids.*
- November 14, Enea F. Pavone, Fondazione Santa Lucia, Roma, Italy, *Brain Monitoring of Erroneous Actions Performed by an Avatar: An EEG Study in Immersive Virtual Reality.*

- November 14, Marilena Vendittelli, Sapienza University of Roma, Italy, *Constrained Motion Planning for Robots*.
- November 26, 2012, *Robots @ DIAG*, event within the euRobotics Week.
- December 7, Paolo Mataloni, Dipartimento di Fisica - "Sapienza" University of Rome, *Un cammino nel mondo quantistico: dai fondamenti della fisica alla tecnologia del futuro*.
- December 11, Moshe Vardi, Rice University, *Database Queries: Logic and Complexity*.
- December 11, Aniello Murano, Università degli Studi di Napoli Federico II, *Reasoning About Strategies*.
- December 13, Erkki Somersalo, Case Western Reserve, Department of Mathematics, Cleveland OH, *Hierarchical Bayesian Beamformers in Electroneurography*.
- December 13, Daniela Calvetti, Case Western Reserve, Department of Mathematics, Cleveland OH, *Bayesian source separation in MEG*.
- December 20, Emiliano Traversi, Fakultät für Mathematik, TU Dortmund, *Separable non-convex underestimators for binary quadratic programming*.

2.7 Awards and Recognitions

- Giorgio Ausiello: appointed Professor Emeritus, 2012.
- Roberto Baldoni: received an IBM Faculty Award, 2012.
- Fabio D'Andreagiovanni: received an Excellence Award of the ESF-JSPS Frontier Science Conference for Young Researchers "Mathematics for Innovation: Large and Complex Systems", 2012.
- Fabio D'Andreagiovanni: received Sapienza Editrice Doctoral Dissertation Award, 2012.
- Giuseppe De Giacomo: elected as ECCAI Fellow, 2012.
- Alessandro De Luca and Fabrizio Flacco: Best Paper Award at the 4th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob 2012), 2012.
- Alessandro De Luca: Vice-President for Publication Activities of the IEEE Robotics and Automation Society, 2012-2013.
- Alberto Isidori: elected as Socio Corrispondente dell'Accademia dei Lincei - Classe di Scienze Fisiche, Matematiche e Naturali, 2012.
- Alberto Isidori: received the IEEE Control Systems Award, 2012

- Stefano Leonardi: received a Google Research Award, 2012.
- Carlo Mannino (on leave): second prize winner in the Railway Application Section Competition of INFORMS, 2012.
- Francesco Quaglia, with S. Peluso, P. Ruivo, P. Romano, and L. Rodrigues: Future Grid 2012 Project Challenge Award assigned to the Cloud-TM FP7 Project, 2012.
- Francesca Sanna-Randaccio: elected as Dean of EIBA Fellows (European Academy of International Business, <http://www.eiba-online.org/>), 2012.
- Francesca Sanna-Randaccio: elected as Member of EIASM Board (European Institute for Advanced Studies in Management, <http://www.eiasm.org/r/about-eiasm>), 2012.
- Jlenia Toppi: Travel Award as a finalist in Student Paper Competition IEEE EMBC 2012.

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 € 256.512, P2P-NEXT - Next generation peer-to-peer content delivery platform, F. Delli Priscoli, ending 30-04-2012
- 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 MULTi-level 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-Marie Curie IIF € 158.758, SNAPS - Social networks: algorithms, privacy and security, S. Leonardi, ending 02-04-2012
- 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 2013
- FP7-SME € 330.000, Collective - emerging communities for collective innovation: ict operational tool and supporting methodologies for sme associations, C. Leporelli, ending 31-12-2012
- 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
- EUREKA Eurostars € 110.500, BLEND - Blending technologies for ubiquitous real-time data access, R. Baldoni, ending 02-05-2012
- EUREKA Eurostars € 75.000, pharmaAID, A. Vitaletti, ending 30-06-2012
- ENIAC € 85.000, MODERN - Modeling and design of reliable nanoelectronics devices, G. Di Pillo, ending February 2012
- LLP KA3 € 59.863, E-Learning Fitness, U. Nanni, ending 31-12-2013
- LLP Leonardo da Vinci € 45.114, Understand IT, M. Temperini, ending 26-12-2012

Contracts with Italian Institutions

- ASI – Agenzia Spaziale Italiana € 294.735, SARFIRE – Spaceborn SAR imagery and environmental data fusion for the dynamical evaluation of land regions susceptibility to fire, F. Pirri, ending 09-02-2012
- ENEA - Centro Ricerche Frascati € 30.000, Studio e pre-progettazione di un sistema robotizzato per l'ispezione visiva della camera FTU del Centro Ricerche ENEA di Frascati, S. Monaco, ending 16-12-2012
- 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
- Herzum Software Srl € 56.250, Piano innovazione aziendale (PIA) relativo al progetto di ricerca e sviluppo tecnologico "COSMFactory", M. Mecella, ending 19-01-2012
- 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

- INNOVA SPA € 30.000 Studio/ricerca nell'ambito del progetto PREVIU - Bando Por Lazio 2007-2013 - Frontiere Tecnologiche, A. Nastasi, F. Nonino, ending 03-11-2012
- DUEL SPA € 53.000 Studio/ricerca sul tema: Studio e sviluppo di tecniche di visione artificiale ed intelligenza artificiale, D. Nardi, L. Iocchi, ending 31-07-2012
- TELECOM ITALIA SPA € 25.000 Studio/ricerca sul tema: Sviluppo di una ontologia e mapping tra ontologia e sorgenti di dati, M. Lenzerini, ending 31-12-2012
- 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 strumento 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
- SMARTCARE SRL € 120.000 Studio/ricerca sul tema: Sviluppo di una ontologia e mapping tra ontologia e sorgenti di dati, M. Lenzerini, ending 31-12-2012
- 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
- ADF SERVICE SRL € 12.000 Studio/ricerca concernente l'analisi dei costi e dei risultati economico-finanziari di un campione delle imprese di distribuzione farmaceutica e simulazione degli effetti di possibili mutamenti nella remunerazione che il SSN prevede per la distribuzione di farmaci di fascia A, C. Leporelli, ending 14-12-2012
- 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
- SPES SCPA € 26.000 Studio/ricerca sul tema "sviluppo nuove soluzioni tecnologiche basate su tecnologie wireless" nell'ambito del progetto Hybrid Cappe Multifunzione - Industria 2015 A. Marchetti, A. Vitaletti, ending 31-12-2012
- ISTAT – Istituto Nazionale di Statistica, € 40.000, Studio/ricerca sul tema: Realizzazione di nuove metodologie basate sull'utilizzo di tecnologie di Ricerca Operativa per il controllo a livello micro-macro dei dati, implementazione delle stesse, G. Di Pillo, ending 11-10-2012
- DUEL SpA, € 110.000, Studio/ricerca sul tema: Sistema avanzato per pubblicità virtuale tridimensionale, D. Nardi, L. Carlucci Aiello, L. Iocchi, ending 12/06/12

- IBM Italia Spa, € 300.000, Studio/ricerca sul tema: Sviluppo di una ontologia in ambito bancario, e Mapping tra ontologie e sorgenti di dati, M. Lenzerini, ending 31/07/12

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 Scrl, ending 12/12/2013
- CRAT Consorzio per la ricerca nell'automatica e nelle telecomunicazioni, ending 31/03/2012
- EUROGROUP Consulting Italia srl, ending 28-11-2013
- Fondazione S. Lucia, ending 27-07-2015
- Università IUAV di Venezia, ending 03-10-2012

3 Research

3.1 Algorithm Design and Engineering

Research lines:

- Principles of Design and Analysis of Algorithms
- Experimental Algorithmics
- External Memory and Streaming Algorithms for Massive Data Processing
- Incremental Algorithms and Dynamic Data Structures
- Approximation and On-line Algorithms
- Algorithmic Game Theory
- 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: Vincenzo Bonifaci, 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 algorithmic code;

- 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:

- *AlgoDEEP: Algorithmic Challenges for Data-intensive Processing on Emerging Computing Platforms* - March 2010, September 2012 - PRIN MIUR.
- *FRONTS: Foundations of Adaptive Networked Societies of Tiny Artefacts* - March 2008, March 2012 - EU FP7 FET.
- *eLF: eLearning Fitness* - January 2011, December 2013 - EU EACEA LLP ka3-ICT.

Journals

- [1] Bonifaci V., Marchetti-Spaccamela A. and Stiller S. A Constant-Approximate Feasibility Test for Multiprocessor Real-Time Scheduling. *Algorithmica*, **62**(3-4), pp. 1034–1049, 2012.
- [2] Bonifaci V. and Marchetti-Spaccamela A. Feasibility Analysis of Sporadic Real-Time Multiprocessor Task Systems. *Algorithmica*, **63**(4), pp. 763–780, 2012.
- [3] Wiese A., Bonifaci V. and Baruah S. Partitioned EDF scheduling on a few types of unrelated multiprocessors. *Real-Time Systems*, 2012. doi:10.1007/s11241-012-9164-y.
- [4] Ausiello G., Boria N., Giannakos A., Lucarelli G. and Paschos V. Online maximum k-coverage. *Discrete Applied Mathematics*, **160**(13-14), pp. 1901–1913, 2012.
- [5] Ausiello G., Firmani D. and Laura L. Real-time monitoring of undirected networks: Articulation points, bridges, and connected and biconnected components. *Networks*, **59**(3), pp. 275–288, 2012.
- [6] Italiano G.F., Laura L. and Santaroni F. Finding strong bridges and strong articulation points in linear time. *Theoretical Computer Science*, **447**, pp. 74–84, 2012.
- [7] Nanni U., Betsou F., Riondino S., Rossetti L., Spila A., Valente M.G., Della Morte D., Palmirota R., Roselli M., Ferroni P. and Guadagni F. SPRECware: software tools for Standard PREanalytical Code (SPREC) labelling – effective exchange and search of stored biospecimens. *The International Journal of Biological Markers*, **27**(3), pp. 272–279, 2012. doi:10.5301/JBM.2012.9718.
- [8] Nanni U. and Temperini M. eLearning for knowledge management in collaborative architectural design. *International Journal of Design Sciences & Technology*, **19**(2), pp. 105–121, 2012.
- [9] Lehmann S., Guadagni F., Moore H., Ashton G., Barnes M., Benson E., Clements J., Koppandi I., Coppola D., Demiroglu S.Y., DeSouza Y., De Wilde A., Duker J., Eliason J., Glazer B., Harding K., Jeon J.P., Kessler J., Kokkat T., Nanni U., Shea K., Skubitz A., Somiari S., Tybring G., Gunter E. and Betsou. F. Standard preanalytical coding for biospecimens: Review and implementation of the Sample PRE-analytical Code (SPREC). *Biopreservation and Biobanking*, **10**(4), pp. 366–374, 2012. DOI:10.1089/bio.2012.0012.

- [10] Acuna V., Milreu P.V., Cottret L., Marchetti-Spaccamela A., Stougie L and Sagot M.F. Algorithms and complexity of enumerating minimal precursor sets in genome-wide metabolic networks. *Bioinformatics*, **28**(19), pp. 2474–2483, 2012. <http://dx.doi.org/10.1093/bioinformatics/bts423>.
- [11] Epstein L., Levin A., Marchetti-Spaccamela A., Megow N., Mestre J., Skutella M and Stougie L. Universal Sequencing on an Unreliable Machine. *SIAM J. Comput.*, **41**(3), pp. 565–586, 2012. DOI: <http://dx.doi.org/10.1137/110844210>.
- [12] Acuna V., Birmelé E., Cottret L., Crescenzi P., Jourdan F., Lacroix V., Marchetti-Spaccamela A., Marino A., Vieira Milreu P., Sagot M.F. and Stougie L. Telling stories: Enumerating maximal directed acyclic graphs with a constrained set of sources and targets. *Theoretical Computer Science*, **457**, pp. 1–9, 2012. <http://dx.doi.org/10.1016/j.tcs.2012.07.023>.

Conference proceedings

- [13] Coppa E., Demetrescu C. and Finocchi I. Input-Sensitive Profiling. *Proceedings of the 33rd ACM SIGPLAN Conference on Programming Language Design and Implementation (PLDI 2012)*, pp. 89–98, 2012.
- [14] Ausiello G., Demetrescu C., Finocchi I. and Firmani D. k-Calling Context Profiling. *Proceedings of the 27th ACM SIGPLAN Conference on Object-Oriented Programming, Systems, Languages and Applications (OOPSLA 2012)*, pp. 867–878, 2012.
- [15] Ausiello G., Italiano G.F., Laura L., Nanni U. and Sarracco F. Structure Theorems for Optimum Hyperpaths in Directed Hypergraphs. *Combinatorial Optimization - Second International Symposium, ISCO 2012, Athens, Greece, April 19-21, 2012 - LNCS Vol. 7422*, pp. 1–14, 2012.
- [16] Ausiello G., Firmani D., and Laura L. Real-time analysis of critical nodes in network cores. *Proceedings of the 8th International Wireless Communications and Mobile Computing Conference (IWCMC 2012)*, pp. 42–46, 2012.
- [17] Firmani D., Italiano G.F., Laura L., Orlandi A. and Santaroni F. Computing strong articulation points and strong bridges in large scale graphs. *Proceedings of the 11th International Symposium on Experimental Algorithms (SEA 2012)*, pp. 195–207, 2012.
- [18] Georgiadis L., Italiano G.F., Laura L. and Santaroni F. An Experimental Study of Dynamic Dominators. *Proceedings of the 20th Annual European Symposium on Algorithms (ESA12)*, pp. 491–502, 2012.
- [19] D’Amore F., Laura L., Luciani L. and Pagliarini F. Planning, Designing and Evaluating Multiple eGovernment Interventions. *Proc. of the ICE-B - International Conference on e-Business*, pp. 85–92, 2012.
- [20] Salcedo-Sanz S., Carro-Calvo L., Portilla-Figueras A., Naldi M., Laura L. and Italiano G.F. Traffic vs topology in network clustering: Does it matter?. *Proceedings of the 8th*

International Wireless Communications and Mobile Computing Conference, IWCMC 2012, pp. 36–41, 2012.

- [21] Marchetti-Spaccamela A., Rutten C., van der Ster S. and Wiese A. Assigning Sporadic Tasks to Unrelated Parallel Machines. *39th International Colloquium on Automata, Languages, and Programming (ICALP 2012)*, pp. 665–676, 2012. http://dx.doi.org/10.1007/978-3-642-31594-7_56.

Submitted papers, technical reports and others

- [22] Cormode G. and Firmani D. On Unifying the Space of L0 Sampling Algorithms. *Proceedings of SIAM Meeting on Algorithm Engineering & Experiments (ALENEX 2013)*, pp. 163–172, 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, Domenico Lembo, Maurizio Lenzerini, Daniele Nardi, Fabio Patrizi, Antonella Poggi, Riccardo Rosati

PhD Students: Cristina Civili, Marco Console, Riccardo De Masellis, Floriana Di Pinto, Paolo Felli, Guglielmo Gemignani, Lorenzo Lepore, Valerio Santarelli, Domenico Fabio Savo.

Post Docs: Matteo Leonetti, Gabriele Randelli, Marco Ruzzi.

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:

- Giuseppe De Giacomo has been Local Organization co-Chair (with Marco Schaerf) of the 13th International Conference on Principles of Knowledge Representation and Reasoning (KR2012).
- Giuseppe De Giacomo has been Area Chair of the AAAI 2012 Conference on Artificial Intelligence.
- Domenico Lembo has been General Chair of the Twenty-fifth International Workshop on Description Logics (DL 2012), held in Rome, June 7-10, 2012.
- Domenico Lembo is Program co-Chair of the Seventh International Conference on Web Reasoning and Rule Systems (RR 2013), which will be held in Mannheim, Germany, 27-29 July 2013.
- Maurizio Lenzerini, *Ontology-based data management: present and future*, keynote talk at the 13th International Conference on Principles of Knowledge Representation and Reasoning, KR 2012.
- Daniele Nardi has been invited to the Workshop on *Intelligent Human- Machine Collaboration*, by the National Academy of Sciences, Washington, USA, 2012.

- Daniele Nardi has been visiting Professor at Carnegie Mellon University, Computer Science Department, 2012.
- Daniele Nardi has been President of the RoboCup Federation, 2012.
- Fabio Patrizi has been Local Organization co-Chair of the CILC 2012 (Convegno italiano di Logica Computazionale).
- Riccardo Rosati has been Program co-Chair of the 14th International Workshop on Nonmonotonic Reasoning (NMR 2012).
- The system *Speaky for Robots* has been demonstrated at the AAAI 2012 Conference on Artificial Intelligence, 2012.

Projects:

- *OPTIQUE* - Scalable End-User Access to Big Data, November 2012 - October 2016 (EU FP7), Maurizio Lenzerini.
- *Joint project with Smartcare S.r.l.* : Modellazione ontologica per il sistema informativo del debito pubblico, Maurizio Lenzerini, April 2012 - December 2012.
- *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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- [20] Calvanese D., De Giacomo G., Lembo D., Lenzerini M., and Rosati R. Data complexity of query answering in description logics. To appear in *Artificial Intelligence*, 2013.
- [21] Kollar T., Perera V., Nardi D., and Veloso M. Learning environmental knowledge from task-based human-robot dialog. To appear in *Proc. of the IEEE International Conference on Robotics and Automation (ICRA-13)*, 2013.
- [22] Lembo D., Lenzerini M., Rosati R., Ruzzi M., and Savo D. F. Inconsistency-tolerant query answering in ontology-based data access. Submitted to an international journal, 2013.
- [23] Lembo D., Santarelli V., and Savo D. F. Graph-based ontology classification in owl 2 ql. Submitted to an international conference, 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.

Journals

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- [2] Bernt F., Dahl G., Mannino C. Computing optimal recovery policies for financial markets, *Operations Research* 60(Nov/Dec), 2012.
- [3] Bruni R., Cesarone F., Scozzari A., Tardella F. A New Stochastic Dominance Approach to Enhanced Index Tracking Problems, *Economics Bulletin* 32(4), 3460-3470, 2012.
- [4] Bianchi G., Bruni R., Reale A. Information Reconstruction via Discrete Optimization for Agricultural Census Data, *Applied Mathematical Sciences* 6(125), 6241-6251, 2012.
- [5] D'Andreagiovanni F. Pure 0-1 Programming approaches to Wireless Network Design, *4OR: A Quarterly Journal of Operations Research*, doi: 10.1007/s10288-011-0162-z, 2012.

Articles in books

- [6] Bianchi G., Bruni R., Reale A. Open Source Integer Linear Programming Solvers for Error Localization in Numerical Data, in N. Torelli, F. Pesarin, A. Bar-Hen (Eds.), *Advances in Theoretical and Applied Statistics*, Springer, New York, 2012.

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- [7] D'Andreagiovanni F. New perspectives on Wireless Network Design. Strong, stable and robust 0-1 models by Power Discretization, Sapienza Università Editrice, Roma, 2012.

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- [12] Büsing C., D'Andreagiovanni F. New results about robust network design under multiband uncertainty, in *Proceedings of the 11th INFORMS Telecommunications Conference*, Boca Raton, USA, 2012.
- [13] D'Andreagiovanni F., Gröthschel M. Exploiting dominance criteria in the design of survivable multi-layer networks, in *Proceedings of the 11th INFORMS Telecommunications Conference*, Boca Raton, USA, 2012.
- [14] Bley A., D'Andreagiovanni F., Karch D. WDM replacement scheduling, in *Proceedings of the 11th INFORMS Telecommunications Conference*, Boca Raton, USA, 2012.
- [15] D'Andreagiovanni F., Mannino C., Sassano A. Solving Wireless Network Design Problems by Cycle Deletion, in *Proceedings of High Performance Scientific Computing (HPSC 2012)*, Hanoi, Vietnam, 2012
- [16] Büsing C., D'Andreagiovanni F. New Results about Multi-band Uncertainty in Robust Optimization, in *Proceedings of SEA 2012, the 11th Symposium on Experimental Algorithms*, LNCS 7276, pp. 63-74. Springer, Heidelberg, 2012.
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- [18] D'Andreagiovanni F. A Hybrid Exact-ACO Algorithm for the Joint Scheduling, Power and Cluster Assignment in Cooperative Wireless Networks, to appear in *Proceedings of BIONETICS 2012*, LNCS. Springer, Heidelberg, 2012.

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- [24] Bianchi G., Bruni R., Reale A. Balancing of Agricultural Census Data by Using Discrete Optimization, submitted to *Optimization Letters*.
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- [26] Büsing C., D'Andreagiovanni F. Robust Optimization under Multi-band Uncertainty - Part I: Theory, submitted for publication, 2012.

3.4 Computer Networks and Pervasive Systems

Research lines:

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

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

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

The miniaturization of electronic devices and the advancements in telecommunications, make it possible the realization of ubiquitous pervasive systems, i.e. systems in which information processing has been thoroughly and transparently integrated into everyday objects and activities. These systems are composed of heterogeneous tiny artefacts such as wireless sensor nodes, RFID and NFC tags and readers, mobile phones etc. Such devices are often constrained in their computational and energy resources and are organized in large networks that do not rely on wired infrastructures.

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

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

We are also interested in solving complex communications primitives such as service discovery and event-based data diffusion, with the final goal of characterizing sensors networks as a data storage and retrieval. In the future we plan to address security and privacy issues of such networks. In fact the limited available resources requires new

techniques and algorithms. We complement our research with experimental work that is based on simulations (using network simulators such as NS2, OMNET++ and Shawn), and on test-beds (e.g. we run a permanent test-bed of wireless sensor network to monitor the ancient roman remains at the basement of DIAG). We are also interested in experimenting our ideas on smart mobile phones, such as the iPhone, in the context of augmented reality and fully decentralized recommendations.

Projects:

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

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- [2] M. Platania, R. Beraldi, G. Lodi, L. Querzoni and R. Baldoni Supporting NGNs Core Software Services: A Hybrid Architecture and its Performance Analysis *J. Network Syst. Manage.*, 20(2), 2012.
- [3] Hussein M. Alnuweiri, M.R. Rebai, and Roberto Beraldi, Network-coding based event diffusion for wireless networks using semi-broadcasting. *Ad Hoc Networks*, 10(6): 871–885, 2012.
- [4] Becchetti L., Filipponi L., and Vitaletti A. Privacy support in people-centric sensing. *Journal of Communications*, 7(8):606–621, 2012.
- [5] V. Bonifaci, A. Marchetti-Spaccamela and S. Stiller, A Constant-Approximate Feasibility Test for Multiprocessor Real-Time Scheduling *Algorithmica*, 62 (2–4), pages 1034–1049, 2012.
- [6] V. Bonifaci, Ho-Leung Chan, A. Marchetti-Spaccamela and N. Megow Algorithms and complexity for periodic real-time scheduling, *ACM Transactions on Algorithms*, 9(1), 2012.

- [7] S. K. Baruah, V. Bonifaci, G. D'Angelo, Haohan Li, A. Marchetti-Spaccamela, N. Megow, L. Stougie, Scheduling Real-Time Mixed-Criticality Jobs *IEEE Trans. Computers*, 61 (8), 2012

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- [8] L. Becchetti, L. Bergamini, F. Ficarola, F. Salvatore and A. Vitaletti First Experiences with the Implementation and Evaluation of Population Protocols on Physical Devices. In *Proceedings of IEEE International Conference on Green Computing and Communications (GreenCom)*, pages 335–342, 2012.
- [9] Massri K., Vernata A., and Vitaletti A. Routing protocols for delay tolerant networks: a quantitative evaluation. In *Proceedings of the 7th ACM workshop on Performance monitoring and measurement of heterogeneous wireless and wired networks (PM2HW2N '12)*, pages 107–114, 2012.
- [10] Becchetti L., Bergamini L., Ficarola F. and Vitaletti A. Population protocols on real social networks. In *Proceedings of the Fifth Workshop on Social Network Systems (SNS '12)*, 2012.
- [11] C. Esposito, S. Russo, R. Beraldi, M. Platania and R. Baldoni, Achieving Reliable and Timely Event Dissemination over WAN, In *Proc. ICDCN*, pages 265–280, 2012
- [12] H. Qusa, R. Baldoni, R. Beraldi, A Privacy Preserving Scalable Architecture for Collaborative Event Correlation, In *Proceedings TrustCom*, pages 837–843, 2012
- [13] S. K. Baruah, V. Bonifaci, G. D'Angelo, Haohan Li, A. Marchetti-Spaccamela, S. van der Ster and L. Stougie, The Preemptive Uniprocessor Scheduling of Mixed-Criticality Implicit-Deadline Sporadic Task Systems, In *Proceedings ECRTS*, pages 145–154, 2012
- [14] S. K. Baruah, V. Bonifaci, A. Marchetti-Spaccamela, L. Stougie, and A. Wiese A Generalized Parallel Task Model for Recurrent Real-time Processes In *Proceedings of Real Time Systems Symposium RTSS*, pages 63–72, 2012

Submitted papers, technical reports and others

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

3.5 Computer Vision, Computer Graphics, and Perception

Research lines:

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

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

PhD Students: Bruno Cafaro, Mario Gianni, Valsamis Ntouskos, Nadine Abu Rumman.

Post Docs: Panagiotis Papadakis, Matia Pizzoli, Arnab Sinha.

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

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

Concerning Geometric Modelling and Multi-view Geometry we developed multi-view methods for the gaze machine and for scene reconstruction. Scene understanding has also been developed according to a specific model of natural images. Research issues, specifically in vision, have also led the developing a new segmentation method and the description of an innovative surveillance system, that is already at work in Venice.

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

Projects:

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

Journals

- [1] Blisard S., Carmichael T., Ding L., Finin T., Frost W., Graesser A. C., Hadzikadic M., Kagal L., Kruijff G. M., Langley P., Lester J. C., McGuinness D. L., Mostow J., Papadakis P., Pirri P., Prasad R., Stoyanchev S., Varakantham P., Reports of the AAAI 2011 Fall Symposia. *AI Magazine*, 33(1), 2012.
- [2] Fratarcangeli M., Position-based facial animation synthesis. *Computer Animation and Virtual Worlds*, 2012.

Conference proceedings

- [3] Ntouskos V., Papadakis P., Pirri F., A Comprehensive Analysis of Human Motion Capture Data for Action Recognition. *Proceedings of the International Conference on Computer Vision Theory and Applications*, Rome, IT, 2012.
- [4] Papadakis P., Gianni M., Pizzoli M., Pirri F., Constraint-free Topological Mapping and Path Planning by Maxima Detection of the Kernel Spatial Clearance Density. *Proceedings of the International Conference on Pattern Recognition Applications and Methods*, Vilamoura, PT, 2012.
- [5] Cafaro B., Canale S., De Santis A., Iacoviello D., Pirri F., SVM based feature selection for X-SAR images. *IEEE International Geoscience and Remote Sensing Symposium, Remote Sensing for a Dynamic Earth*, 2012.
- [6] Pirri F., Pizzoli M., Sinha A., Coherence Fields for 3D Saliency Prediction. *Proceedings of the International Conference on Biological Inspired Cognitive Architectures*, Palermo, IT, 2012.

- [7] Pirri F., Pizzoli M., Sinha A., A Preliminary Account of 3D Visual Search. *Proceedings of the First International Workshop on Cognitive Assistive Systems*, Vilamoura, PT, 2012.
- [8] Papadakis P., Pirri F., 3D Mobility Learning and Regression of Articulated, Tracked Robotic Vehicles by Physics-based Optimization. *Proceedings of the Eurographics Workshop on Virtual Reality Interaction and Physical Simulation*, , Darmstadt, DE, 2012.
- [9] Gianni M., Papadakis P., Pirri F., Shifting and inhibition in cognitive control. *Proceedings of the IROS 2012 Workshop on Cognitive Neuroscience Robotics*, Vilamoura, PT, 2012.
- [10] Kruijff G., Janicek M., Keshavdas S., Larochelle B., Zender H., Smets N. J. J. M., Mioch T., Neerincx M. A., van Diggelen J., Colas F., Liu M., Pomerleau F., Siegwart R., Hlavac V., Svoboda T., Petrecek T., Reinstein M., Zimmermann K., Pirri F., Gianni M., Papadakis P., Sinha A., Balmer P., Tomatis N., Worst R., Linder T., Surmann H., Tretyakov V., Corrao S., Pratzler-Wanczura S., Sulk M., Experience in System Design for Human-Robot Teaming in Urban Search & Rescue. *Proceedings of 8th International Conference on Field and Service Robotics*, 2012.
- [11] Mancas M., Pirri F., Pizzoli M., Human-motion saliency in multi-motion scenes and in close interaction. *Lecture Notes in Computer Science*, 2012.
- [12] Kruijff G. M., Pirri F., Gianni M., Papadakis P., Pizzoli M., Sinha A., Pianese E., Corrao S., Priori F., Febrini S., Angeletti S., Tretyakov V., Linder T., Rescue Robots at Earthquake-Hit Mirandola, Italy: a Field Report. *Proceedings of the 10th IEEE International Symposium of Safety Security and Rescue Robotics*, 2012.
- [13] Cafaro B., Canale S., Pirri F., X-SAR SpotLight images feature selection and water segmentation. *Proceedings of the 2012 IEEE International Conference on Imaging Systems and Techniques (IST)*, 2012.
- [14] Bloisi D., Iocchi L., Independent Multimodal Background Subtraction. *Proc. of the Third Int. Conf. on Computational Modeling of Objects Presented in Images: Fundamentals, Methods and Applications*, Rome, IT, 2012.

PhD theses

- [15] Pizzoli M., Visual saliency in the wild: moving the analysis of gaze behaviors to three-dimensional, unstructured environments. PhD thesis, "Sapienza" University of Rome, Department of Computer and System Sciences, Rome, Italy, 2012.

Submitted papers, technical reports and others

- [16] Ntouskos V., Papadakis P., Pirri F., Discriminative Sequence Back-Constrained GP-LVM for MOCAP Based Action Recognition. *2nd International Conference on Pattern Recognition Applications and Methods*, to appear.

3.6 Continuous Optimization

Research lines:

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

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

PhD Students: Valentina Bracaglia, Umberto Dellepiane, Marianna De Santis, Andrea Ianni, Lorenzo Lampariello, Vittorio Latorre, Andrea Manno, Olimpia Ottaviani, Mauro Piacentini, Stefania Renzi, Simone Sagratella, Serena Teobaldo.

Post Docs: Francesco Rinaldi.

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

The following areas are object of current research.

- Exact penalty and augmented Lagrangian methods, still constituting the founding block of many optimization methods and a springboard for many of the studies of the group.
- Non-monotone methods and decomposition techniques for the solution of difficult large-scale nonlinear optimization problems and nonlinear equations.

- Preconditioning Newton-Krylov methods in nonconvex large scale optimization, which is an important tool for efficiently solving large difficult problems.
- Derivative-free algorithms, of special interest in many engineering applications where even the calculation of function values is problematic and very time-consuming.
- Global optimization, which is an essential tool for solving problems where local non-global solutions may be meaningless.
- Semidefinite programming, that plays an essential role in the development of efficient algorithms for solving relaxations of non-convex and integer problems.
- Finite dimensional variational inequalities and complementarity problems, which often arise in modelling a wide array of real-world problems where competition is involved.
- Generalized Nash equilibrium problems, which are emerging as a winning way of looking at several classical and non-classical engineering problems.
- Training methods for neural networks and support vector machines, for constructing surrogate models of complex systems from sparse data through learning techniques.
- Mixed Integer Nonlinear Programming (MINLP) problems that combine combinatorial aspects with nonlinearities.

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

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

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

Projects:

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

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- [23] Facchinei F., Pang J.-S., and Scutari G. Non-cooperative games with minmax objectives. Submitted to *Computational Optimization and Applications*.
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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, Floriana Di Pinto, Paolo Felli, Francesco Leotta, Lorenzo Lepore, Andrea Marrella, Alessandro Russo, Valerio Santarelli, Domenico Fabio Savo.

Post Docs: Marco Ruzzi.

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 2012, 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:

- Giuseppe De Giacomo has been Chair of the Panel “Conceptual Models for Data-Aware Processes” at 31st International Conference on Conceptual Modeling (ER 2012).
- Maurizio Lenzerini, “Inconsistency tolerance in ontology-based data management”, keynote talk at the On The Move Federated Conferences and Workshops , OTM 2012.
- Maurizio Lenzerini, “Ontology-based data management”, keynote talk at the 6th Alberto Mendelzon International Workshop on Foundations of Data Management, AMW 2012.
- Maurizio Lenzerini, “Query rewriting for ontology-based big data access”, invited talk at the International Workshop on Global Scientific Data Infrastructures: The Findability Challenge, 2012.

- Stavros Vassos is co-Chair of the "3rd Planning in Games Workshop" of the 23rd International Conference on Automated Planning and Scheduling (ICAPS 2013) that will take place in Rome, Italy, 10-14 June, 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).
- *COLLECTIVE - Emerging communities for collective innovation: ICT Operational tool and supporting methodologies for SME Associations* January 2010 - December 2012 (EU FP7).
- Project funded by Regione Lazio: *Integrazione semantica di dati e servizi per le aziende in rete*, 2011 - 2014.
- Project funded by Telecom Italia: *Sviluppo di ontologia per il "Dynamic Inventory"*, September 2011 - December 2012.
- Open Collaboration Research Agreement W0954341, joint with Rick Hull of IBM T. J. Watson Research Center, NY, on *Data aware business processes and operation, through an artifact-centric approach*, 2009-2013.
- 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.
- Project funded by Regione Calabria: *PIA COSM Factory*, 2010 - 2012.
- Research project funded by Sapienza: *Graph-based data processing*, November 2011 - November 2012.

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- [9] Cossu F., Marrella A., Mecella M., Russo A., Bertazzoni G., Suppa M., and Grasso F. Improving Operational Support in Hospital Wards through Vocal Interfaces and Process-Awareness. In *Proceedings of the 25th IEEE International Symposium on Computer-Based Medical Systems (CBMS 2012)*, 2012.
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3.8 Distributed Systems

Research lines:

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

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

PhD Students: Leonardo Aniello, Adriano Cerocchi, Giuseppe Antonio Di Luna, Luca Montanari, Fabio Petroni, Hani Qusa.

Post Docs: 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 super-computing, and distributed resource sharing services, is boosting their importance. The theoretical effort is also accompanied by several practical projects in the area of smart environments, namely *SOFIA*, *SM4All* and *Greener Buildings*, and in collaborative security, namely *CoMiFin*, that motivate the foundational research.

Projects:

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

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- [2] Baldoni R. Federated Identity Management Systems in e-Government: the Case of Italy. *Electronic Government: An International Journal*, 8(1):64–84, 2012.
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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: Pierangelo Di Sanzo, Roberto Palmieri, Alessandro Pellegrini, Sebastiano Peluso, Diego Rughetti, Roberto Vitali.

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

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

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

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

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

Projects:

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

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- [1] Peluso S., Didona D. and Quaglia F., Supports for transparent object-migration in PDES systems. *Journal of Simulation*, 6(4): 279-293, 2012.
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- [3] Vitali R., Pellegrini A. and Quaglia F., Load sharing for optimistic parallel simulations on multi core machines. *ACM Performance Evaluation Review*, 40(3): 2-11, 2012.
- [4] Quaglia F. and Simmonds R., Special Issue: Principles of Advanced and Distributed Simulation. *Simulation*, 88(7), 2012.
- [5] Quaglia F. and Santoro A., Transparent optimistic synchronization in the high-level architecture via time-management conversion. *ACM Transactions on Modeling and Computer Simulation*, 22(4): 21, 2012.

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- [10] Vitali R., Pellegrini A. and Quaglia F., Assessing Load Sharing within Optimistic Simulation Platforms. In *Proceedings of the 2012 Winter Simulation Conference (WSC)*, Berlin, Germany, Society for Computer Simulation, December 2012.
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- [14] Rughetti D., Di Sanzo P., Ciciani B. and Quaglia F., Machine Learning-based Self-adjusting Concurrency in Software Transactional Memory Systems. In *Proceedings of the 20th IEEE/ACM International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (MASCOTS)*, Arlington, VA, USA, IEEE Computer Society Press, August 2012.
- [15] Pellegrini A., Vitali R., Peluso S. and Quaglia F., Transparent and Efficient Shared-State Management for Optimistic Simulations on Multi-core Machines. In *Proceedings of the 20th IEEE/ACM International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (MASCOTS)*, Arlington, VA, USA, IEEE Computer Society Press, August 2012.
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- [20] Romano P., Palmieri R., Quaglia F., Carvalho N. and Rodrigues L., On Speculative Replication of Transactional Systems. *Journal of Computer and System Sciences*, pending revision.
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3.10 Human-Computer Interaction

Research lines:

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

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

PhD Students: Claudio Di Ciccio, Marco Angelini.

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

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- [12] Sterbini A. and Temperini M. Correcting open-answer questionnaires through a bayesian-network model of peer-based assessment. In *Proc. 11th IEEE International Conference on Information Technology Based Higher Education and Training*, pages 108–113, 2012.
- [13] Sterbini A. and Temperini M. Dealing with open-answer questions in a peer-assessment environment. In *Lecture Notes in Computer Science - Proc. 11th International Conference on Web-based Learning*, pages 240–248, 2012.
- [14] Sterbini A. and Temperini M. Supporting assessment of open answers in a didactic setting. In *Proc. 12th IEEE International Conference on Advanced Learning Technologies*, pages 678–682, 2012.

3.11 Industrial Organization and Management

Research lines:

- Competition, Regulation and Industrial Policy
- 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, Giulia Perruzzi.

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.

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 economic fields. In particular to: (i) the economics and evaluation of science and technology, including empirical investigations on the European higher education systems; (ii) the development of new bibliometric approaches and indicators to assess the scientific competitiveness at country and regional level.

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.

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.

Regulation and competition in the telecommunication and media industries - We study the impact of access regulation on investment in a dynamic framework where developing an infrastructure requires both time and a captive customer base. We define dynamic models to assess whether and when the *ladder of investment* regulatory paradigm induces efficient competitive network investment. In this framework we analyze the credibility and dynamic consistency of multiperiod regulated access price schedules. We analyze the impact of the industry structure (vertical integration or separation) on investment incentives and we assess if vertical separation of the telecommunications incumbent may be an effective and proportionate remedy when the access network is an enduring economic bottleneck. 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 air transport industry - We study the incentives for airports and carriers to vertical cooperation and the effects of competitive pressures in both the airlines and airports markets over these incentives. Specifically, our findings provide theoretical and policy concerns with respect to the analysis of different contracts between airports and their respective dominant airlines and their effects in terms of social welfare, pro or anti competitiveness and the ensuing regulatory requirements.

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.

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- [6] Albino V., Balice A., Dangelico R.M., Iacobone F., The Effect of the Adoption of Environmental Strategies on Green Product Development: A Study of Companies on World Sustainability Indices. *International Journal of Management*, Vol. 29, No. 2: 525-538, 2012. ISSN 0813-0183.
- [7] Albino V., Dangelico R.M., Pontrandolfo P., Do inter-organizational collaborations enhance a firm's environmental performance? A study of the largest U.S. companies. *Journal of Cleaner Production*, Vol. 37: 304-315, 2012.
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- [9] Badin L., Daraio C., Simar L., How to Measure the Impact of Environmental Factors in a Nonparametric Production Model. *European Journal of Operational Research*, 223, 818-833, 2012.

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- [15] D’Alfonso T., Nastasi A., Vertical relations in the aviation industry: a facility rivalry game. *Transportation Research: Part E*, 48 (5), 993-1008, 2012.
- [16] De Toni A.F., Fornasier A. and Nonino F., Organizational Models for Non-Core Processes Management: a Classification framework. *International Journal of Engineering Business Management*, Vol. 4, No. 46, InTech, 2012, (ISSN: 1847-9790).
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- [29] Albino V., Dangelico R.M., Green economy principles applied to cities: an analysis of best performers and the proposal of a set of indicators. *IFKAD-KCWS 2012*, 13-15 June 2012, Matera, Italy. ISBN: 978-88-96687-08-6.

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- [42] Avenali A., D'Annunzio A., Reverberi P., Bundling, Competition and Quality Investment: a Welfare Analysis. *Review of Industrial Organization*, forthcoming.
- [43] 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*, forthcoming.
- [44] Barbot M.C., D'Alfonso T., Why do contracts between airports and airlines fail. *Transportation Research: Part E*, submitted.
- [45] Battistella C., Nonino F., Exploring the impact of motivations on the attraction of innovation roles in open innovation web-based platforms. *Production Planning & Control*, forthcoming.
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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

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

PhD Students: Pietro Aricò, Federica Conte, Elena Previti, Francesca Schettini, Jlenia Toppi.

Post Docs: Fabio Aloise.

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

- Optimal measurement times in filtering problems;
- Modelling and Identification of tumor response to radiations;
- Analysis and modelling of insulin secretion and glucose metabolism;
- Estimation of cerebral connectivity in humans by means of structural and functional models and applications;
- Implementation 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 statistical procedures

for automatic diagnosis, the computational methods for the analysis of genome wide expression data and the topological features and criticalities in metabolic networks.

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

J. Toppi received a Travel Award as a finalist in the Student Paper Competition IEEE EMBC 2012.

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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, Marilena Vendittelli.

PhD Students: Taigo Maria Bonanni, Ricardo Dodds, Guglielmo Gemignani, Thien Nguyen-Duc, Andrea Pennisi, Fabio Previtali, Erfan Shojaei Barjuei.

Post Docs: Matteo Leonetti, Gabriele Randelli, Paolo Stegagno.

Visiting Scholars (from other Universities): Andreas Karwath Univ. Mainz, Germany

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 Guest Editor of the special issue on *Domestic Service Robots in the Real World* for the Journal of Intelligent and Robotic Systems (2012).
- Luca Iocchi has been member of RoboCup@Home Executive Committee and co-organizer of RoboCupHome 2012.
- Luca Iocchi was invited speaker at the IEEE-RAS Safety, Security and Rescue Robotics Summer School, Turkey 2012, and at the International Rescue and at Home Robots Workshop, Thailand 2012.
- Daniele Nardi has been visiting Professor at Carnegie Mellon University, Computer Science Department, 2012.
- Daniele Nardi has been President of the RoboCup Federation, 2012.
- Daniele Nardi has been chair of the Robotics Track of the Autonomous Agents and Multi-Agent Systems, 2012.
- Giuseppe Oriolo has been member of the International Program Committee of the 2nd IFAC Workshop on Multivehicle Systems (MVS 2012) Espoo, Finland, October 2012
- Giuseppe Oriolo has been appointed member of the IFAC Technical Committee 7.5 on Intelligent Autonomous Vehicles for the term 2011-2014
- The SPQR team of humanoid soccer players participated in RoboCup 2012, Mexico City, 2012.

Projects:

- *BEESAFE* - December 2011, April 2013 - Sistemi Software Integrati - Daniele Nardi.
- *Smart Monitoring of Complex Public Scenes* - May 2011, April 2013 - Dept. of Homeland Security (DHS), USA - Daniele Nardi, Luca Iocchi.
- *Sistema pubblicità virtuale 3D (VIVA)* - January 2011, July 2012 - Duel TV - Daniele Nardi, Luca Iocchi.
- *Situation Awareness, Iniziativa Software 2* - April 2010, March 2012 - SESM, SELEX-SI, Finmeccanica - Daniele Nardi.

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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: Andrea Fiaschetti, Andrea Lanna, Francesco Liberati, Guido Oddi, Andi Palo, Martina Panfili, Margherita Petrocchi, Andrea Simeoni, Letterio Zuccaro.

Post Docs: Silvia Canale, Marco Castrucci, Laura Fogliati, Donato Macone, Andrea Mercurio, Silvano Mignanti, Laura Pimpinella, 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:

- *DLC+VT4IP, Distribution Line Carrier: Verification, Integration and Test of PLC Technologies and IP Communication for Utilities* (managed by CRAT) - January 2010, December 2012 - EU ICT FP7 Project.
- *Fi-WARE, Future Internet Core Platform* - May 2011, April 2014 - EU ICT FP7 Project.
- *MONET, Mechanisms for Optimization of Hybrid Ad-hoc and Satellite Networks* (managed by CRAT) - January 2010, June 2012 - EU ICT FP7 Project.
- *nSHIELD, New embedded System architecture for multi-Layer Dependable solutions* - September 2011, August 2014 - EU ARTEMIS-JU Project
- *PLATINO* - July 2012, June 2015 - Progetto MIUR PON.
- *SAFEDEM, Space Assets For Enhanced DEMining Assistance* - January 2011, March 2012 - ESA AO/1-6392/10/NL/CLP Project
- *SMARTV2G, Smart Vehicle to Grid Interface* - June 2011, May 2014 - EU FP7-2011-ICT-GC Project
- *TASS, Total Airport Security System* - April 2010, March 2014 - EU FP7-2011-ICT-GC Project

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- [11] De Persis C., and Frasca P., Self-Triggered Coordination with Ternary Controllers. *Proceedings of 3rd IFAC Workshop on Distributed Estimation and Control in Networked Systems (NecSys'12)*, vol. 3, part 1, pp. 43-48, Santa Barbara, CA, USA, September 14-15 2012.
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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: Andrea Abelli, Giovanni Mattei, Silvia Paris, Daniele Pucci.

Research on nonlinear systems and control at the University Sapienza has been active since the early 70s and, historically, has played a major role worldwide. The geometric approach to nonlinear feedback design, developed in the late 70s, marked the beginning of a new area of research which, in the subsequent decades, has profoundly influenced the development of the entire field. The concept of (nonlinear) feedback equivalence and of zero dynamics, their properties and implications in feedback design, are perhaps the most frequently used concepts in feedback stabilization. The geometric approach also plays a fundamental role in the analysis of systems evolving on Lie groups, with numerous applications to the control of spacecrafts and mobile robots. The natural evolution of the geometric approach to analysis and design of nonlinear systems led to a refinement of concepts underlying the design of nonlinear controllers to the purpose of shaping the steady-state behavior of a system. Currently, this line of research is pursued with the study of problems arising in the regulation of systems possessing unstable zero dynamics and in the development of methods for robust stabilization via measurement feedback. A general framework for robust stabilization reposes of the concept of filtered Lyapunov functions. Tools for the design of composite filtered Lyapunov functions have been developed. Robust and nonlinear control techniques have proven useful to achieve control objectives in the case of restricted information structure, e.g. measurements taking values only in a finite set and/or feedback delivered to the actuators erratically. A major challenge in the research on control with limited information is the design of controllers which are distributed over a network. In this case, the controllers cooperate to achieve

a common goal but have access only to limited information provided by their neighbors. Analysis and design of real control systems integrating devices and computational procedures in a digital context involves ad-hoc methods. Nonlinear discrete-time and sampled data systems are the subjects of an investigation developed at La Sapienza from the early 80s, in a still active cooperation with the Laboratoire des Signaux et Systèmes of the French CNRS. The research activity has been focused on solving nonlinear control problems in discrete-time and on finding digital solutions to continuous-time control systems. One of the major outcome of the investigation has been the settlement of an original approach, mixed by algebraic and geometric concepts, used either to prove the existence of solutions in discrete-time or to compute approximated solutions in the digital context. Two aspects are at the bases of the more recent developments: a new representation of discrete-time dynamics, which provides a natural framework for comparing results from the continuous-time and discrete-time contexts, the concept of exact sampled model under feedback, which can be used to design piecewise continuous controllers in a direct digital context. From the solution to feedback linearization, stabilization, regulation, observer theory, new research lines are in the direction of Lyapunov and passivity based design, inverse optimal control and time delayed systems in discrete-time and under sampling. Particular attention is devoted to the settlement of executable algorithms for computing the proposed solutions. Measurements devices, algorithms, data handling and transmission represent critical aspects in any distributed control problem. The number of devices, their location, the energy consumption, the data-communication links and the distributed data handling are nowadays classical problems in this context. New issues deal with dynamic sensor networks, where mobile platforms are assimilated to intelligent devices, in which motion planning and control problems pose additional requirements and make harder the solution of the task. The full problem formulation as a high dimensional nonlinear dynamics is a challenging interdisciplinary area of research towards easier and cheaper solutions to problems like surveillance, monitoring, decentralized and distributed control. Problems under investigation in this field concern sensor and actuator devices, computation algorithms, local and global coordinated control, network communication protocols, data acquisition and fusion.

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

During 2012, Paolo Di Giamberardino and Daniela Iacoviello organized (with J.Tavares and R.Natal) the International Conference CompIMAGE 2012 - Computational Modeling of Objects Represented in Images: Fundamentals, Methods and Applications, held at this Department (DIAG) on 5–7 September 2012.

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.
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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.

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:

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

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

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

We have also investigated the role played by MNEs in the international technology transfer (ITT) and the implications for the countries involved. An important mechanism for facilitating the international transfer of environmental friendly technologies to developing countries is the so called Clean Development Mechanism (CDM). We have studied the role of CDM in 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 all 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.

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

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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, Antonio Paolillo, Pietro Peliti, Lorenzo Rosa.

Post Docs: Massimo Cefalo, Fabrizio Flacco, Paolo Stegagno.

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

The main research topics are: nonlinear control of robots; iterative learning of repetitive motion; control of manipulators with flexible elements; 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.
- *MEMONET, Multirobot Exploration supported by MOBILE ad-hoc NETWORKS* - March 2010–September 2012 - MIUR PRIN.

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- [26] Stegagno P., Cognetti M., Rosa L., Peliti P., and Oriolo G., Relative localization and identification in a heterogeneous multi-robot system. Accepted for presentation at *2013 IEEE International Conference on Robotics and Automation*, Karlsruhe, DEU, May 2013.

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: Erik Jan van Leeuwen, Łukasz Jeś

Our interest in on algorithmic and game-theoretic methods for characterizing the structure of large-scale complex networks with application to web structure mining and web usage mining. We have focussed so far on developing algorithms for graph based feature extraction and detection of significant patterns that characterize social activities, trust relationships and content quality, and on the design of auction mechanisms that induce desired behaviors by users in network settings.

A large part of our efforts has focused on the study of algorithmic, structural, and computational aspects of networks. In practice, networks have strong structural properties which, once properly understood, can be exploited algorithmically. This invariably leads to stronger computational results than on worst-case networks. We have studied algorithms that can immunize network nodes to stop viruses, for installing optimally landmarks on network nodes, which can help identify and distinguish vertices apart, and we have studied structural properties of particular graph classes, such as claw-free and planar graphs.

In various settings we have to take good decisions in the presence of uncertainty that respect various budget constraints. These settings have lead us to the study of budgeted stochastic optimization problems. We have analyzed a variety of such problems such as stochastic matching or stochastic knapsack, which can have applications on online advertising and resource allocation. We have presented a general approach based on linear-programming that can attack such problems with provable guarantees.

A challenge on the problems that we study is the fact that often the input is revealed online. This means that we must make decisions without being aware of the entire input, yet we must ensure that the solutions produced provide quality guarantees even if the input that arrives in the future is unexpected. This leads to the study of online optimization, and we have shown how several online problems (such as the multicast acknowledgment problem, or the online knapsack) can be addressed. In other settings, the input is

present, but keeps changing; for instance, the structure of the web continually changes, yet we need to keep track of it so as to provide services to the users. This has led to the design of a new framework for analyzing algorithms under such data-evolving scenarios.

The web has now become a medium that humans use to interact and to collaborate with each other. We have thus studied such interactions and have introduced frameworks for organizing humans in their collaborating endeavors. We have identified the presence of authority and peer pressure in social-media sites or in collaboration networks. Along with scientists in the Yahoo! Research group in Barcelona, we have shown how we can identify users whose web browsing behavior is likely to be followed by a large number of internet users. We have also developed a framework for helping users to collaborate among themselves, taking into account various constraints such as load, prior collaboration, fairness, and so on.

Finally, we have designed auction and pricing mechanisms that are able to allocate goods to individuals in an optimal way, for instance, create allocations that optimize the revenue for the seller, or maximize the social welfare, or have the envy-freeness property: every participant is content in the sense that would not like to exchange the outcome for herself with the outcome of any other participant.

Projects:

- *MULTIPLEX: Foundational Research on MULTIllevel 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.
- COGENT: Computational aspects on game theory and uncoordinated networks, 2010–2012, MIUR PRIN.

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