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

Innovation, Internationalization and Environment

Modeling, Simulation, and Control in Biological and Biomedical Systems

Multi-Agent and Multi-Robot Systems

Networked Systems

Nonlinear Systems and Control

Robotics

Web Algorithmics and Data Mining

Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti

Via Ariosto 25, 00185 Roma

www.diag.uniroma1.it

Research Report 2014 Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti

DIPARTIMENTO DI INGEGNERIA INFORMATICA
AUTOMATICA E GESTIONALE ANTONIO RUBERTI

Research Report 2014

SAPIENZA
UNIVERSITÀ DI ROMA

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

Research report 2014

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I edizione: Aprile 2015

Contents

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 2014.

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

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

Basic research is the main goal of DIAG, with a strong emphasis on interdisciplinary research, on applications that stimulate basic research, and with a specific attention to technology transfer and dissemination of results. Collaborations are maintained with researchers in other university departments, research institutions and companies, in Italy and abroad.

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

The faculty of DIAG in 2013 consists of 27 full professors, 23 associate professors, and 29 assistant professors (ricercatori). They provide education at the undergraduate and graduate levels to several programs of the two schools of engineering at Sapienza (*facoltà di Ingegneria dell'informazione, informatica e statistica* and *facoltà di Ingegneria civile ed industriale*), with main responsibility in the curricula in informatics, systems and control, and engineering management. Teaching activities are not illustrated in this report; a description may be found at `http://www.diag.uniroma1.it` under the entry "Teaching". Furthermore, DIAG offers two PhD programs, and cooperates with a PhD program offered by another department. They are briefly described in Section 2.4 of this report.

Research activities at DIAG are organized in 18 research areas. This organization is reflected in the structure of Section 3, where the research areas are described with a short overview of their main research lines, together with the list of people involved, and the collection of publications appeared in 2014.

2 General Information

2.1 Location

The location of DIAG is the building known as "Scuola Silvio Pellico", in Via Ariosto 25, Rome. DIAG is on the web at `http://www.diag.uniroma1.it`.

2.2 Facilities

Library

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

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

Research Laboratories

Several research 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 laboratory is devoted to the development of autonomous systems for operating in unstructured and rescue environments, as well as vision based systems for navigation, environment reconstruction and recognition.
Web: `http://www.diag.uniroma1.it/~alcor`
Head: Fiora PIRRI

Algorithms Engineering Laboratory
Via Ariosto 25 - wing B1
The laboratory is devoted to the engineering and the experimental performance analysis of combinatorial algorithms and their applications.
Web: `http://www.diag.uniroma1.it/~ae`
Head: Camil DEMETRESCU

Automation Laboratory
Via Ariosto 25 - basement
The laboratory is devoted to the training of students on the design and realization of simple control systems.
Head: Claudio GORI GIORGI

BiBiLab - Bioengineering and Bioinformatics Laboratory
Via Ariosto 25 - basement
The laboratory aims to develop interdisciplinary methodologies by integrating diverse fields, such as signal processing, computer science, systems science, and statistics applied to medical and biological sciences, specifically including: modeling of metabolic systems, information processing from raw molecular biological data to solve interesting biological and medical problems, non-invasive estimation of the electrical activity and functional connectivity of the human brain, development of brain-computer interfaces for assistive and rehabilitation purposes.
Head: Serenella SALINARI

DAMSO Laboratory
Via Ariosto 25 - basement
The laboratory aims at developing models and testing efficient algorithms for processing real world data from industrial and biosystems engineering.
Head: Alberto DE SANTIS

Data And Service Integration Laboratory (DASILab)
Via Ariosto 25 - room 213, wing B2
The laboratory is devoted to the development of software research prototypes for service-based and data-integration systems.
Web: `http://www.diag.uniroma1.it/dasilab`
Head: Maurizio LENZERINI
Organization: Massimo MECELLA

E-learning systems and applications laboratory (ELSA)
Via Andrea Doria 5 (Latina)
In the laboratory, advanced e-learning strategies for robotics and control systems are addressed, developed, implemented and tested through the use of real devices (mobile and articulated robots) available by a web based connection.
Web: `http://infocli31.dislt.uniroma1.it/elsa`
Co-Heads: Paolo DI GIAMBERARDINO and Marco TEMPERINI

Joint Lab on Security Research
Via Ariosto 25 - wing B1
The Joint-Lab on security research with Sapienza Innovazione has the mission to create a critical mass of researchers of La Sapienza around system and software security in complex environments. Results of research of the joint-lab are heavily oriented toward innovation and the creation of new technology companies.

Web: http://www.diag.uniroma1.it/~labsec
Head: Roberto BALDONI

Management Engineering Laboratory
Via Ariosto 25 - room A122 and A123, wing A1
The laboratory is devoted to the development of mathematical models and solution algorithms for Management Engineering problems.
Web: http://www.diag.uniroma1.it/~labinggest
Head: Massimo ROMA

Middleware Laboratory - MIDLAB
Via Ariosto 25 - wing B1
The primary goal of MIDLAB is to support leading-edge research and development on middleware, bridging the gap between the latest research results and the current technologies.
Web: http://www.diag.uniroma1.it/~midlab
Head: Roberto BALDONI

Network Control Laboratory
Via Ariosto 25 - room 215, wing A2
The laboratory is devoted to the design, simulation, and experimental validation of advanced resource management, service management and interoperability management procedures for wireless and wired telecommunication networks as well as in energy distribution networks.
Web: http://labreti.ing.uniroma1.it/
Head: Francesco DELLI PRISCOLI

Robotics Laboratory
Via Ariosto 25 - basement
The laboratory is devoted to the development and experimental validation of advanced planning and control techniques for industrial and service robots.
Web: http://www.diag.uniroma1.it/~labrob
Head: Giuseppe ORIOLO

ROCOCO - RObot COgnitivi COoperanti
Via Ariosto 25 - basement
The laboratory of SPQR (Soccer Player Quadruped Robots) teams participating in RoboCup, AIBO, NAO and Rescue Robots.
Web: http://www.diag.uniroma1.it/~labrococo/
Head: Daniele NARDI

Systems and Control Laboratory
Via Ariosto 25 - basement
The laboratory is devoted to the development and experimental verification of new control strategies.

Web: http://www.diag.uniroma1.it/~syscon/
Head: Paolo DI GIAMBERARDINO

Web Algorithmics and Data Mining Laboratory (WADAM)
Via Ariosto 25 - room A221
The laboratory is devoted to the design of algorithms for web and data-mining related problems.
Web: http://wadam.diag.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://www.diag.uniroma1.it/~ficarola/wsn-group/
Head: Andrea VITALETTI

Additional information on the research laboratories may be found at
http://www.diag.uniroma1.it/en/node/60/research-laboratories.

Educational Laboratories

DIAG has also educational laboratories. Moreover, DIAG manages two educational laboratories of the School of Engineering, located outside the DIAG building and used for hands-on teaching and for self-studying. These laboratories are named after Paolo Ercoli, the founder of the Computer science component of the department.

Computer Science Laboratory Paolo Ercoli for introductory courses
Via Tiburtina 205, Roma.
About 150 stations are available for undergraduate teaching.
Person in charge: Umberto NANNI.

PC and Workstations Laboratory Paolo Ercoli for advanced courses
Via Eudossiana 18, Roma.
About 75 PC and workstations are available for the graduate teaching.
Person in charge: Umberto NANNI.

Management Engineering Laboratory
Via Ariosto 25 - room A122 and A123, wing A1
11 PCs are available. The laboratory is devoted to thesis students for the development of mathematical models and solution algorithms for Management Engineering problems.
Web: http://www.diag.uniroma1.it/~labinggest
Person in charge: Massimo ROMA

Additional information on educational laboratories may be found at `http://www.diag.uniroma1.it/en/node/59/teaching-laboratories`.

2.3 People

Head of Department Alberto MARCHETTI SPACCAMELA
Administration Head Giovanna BIANCO

Professors

Giorgio AUSIELLO (emeritus)
Roberto BALDONI
Stefano BATTILOTTI
Luigia CARLUCCI AIELLO
Giuseppe CATALANO
Tiziana CATARCI
Bruno CICIANI
Giuseppe DE GIACOMO
Alessandro DE LUCA
Francesco DELLI PRISCOLI
Gianni DI PILLO (emeritus)
Francisco FACCHINEI
Claudio GORI GIORGI
Alberto ISIDORI (emeritus)
Maurizio LENZERINI
Stefano LEONARDI
Claudio LEPORELLI
Stefano LUCIDI
Alberto MARCHETTI SPACCAMELA
Salvatore MONACO
Umberto NANNI
Daniele NARDI
Alberto NASTASI
Fiora PIRRI
Francesca SANNA RANDACCIO
Antonio SASSANO
Marco SCHAERF

Associate professors

Alessandro AVENALI
Luca BECCHETTI
Luca BENVENUTI
Barbara CAPUTO
Ioannis CHATZIGIANNAKIS
Fabrizio D'AMORE
Cinzia DARAIO
Camil DEMETRESCU
Alberto DE SANTIS
Lorenzo FARINA
Luca IOCCHI
Domenico LAISE
Leonardo LANARI
Paolo LIBERATORE
Carlo MANNINO (on leave)
Marco Antonio MARINI
Giuseppe ORIOLO
Laura PALAGI
Francesco QUAGLIA
Pierfrancesco REVERBERI
Massimo ROMA
Riccardo ROSATI
Serenella SALINARI (up to October 2014)
Silvio SALZA
Giuseppe SANTUCCI
Marco TEMPERINI

Assistant professors (ricercatori)

Aris ANAGNOSTOPOULOS
Laura ASTOLFI
Roberto BERALDI
Domenico Daniele BLOISI
Silvia BONOMI (up to November 2014)
Renato BRUNI
Claudia CALIFANO
Febo CINCOTTI
Rosa Maria DANGELICO
Claudio DE PERSIS (on leave)
Paolo DI GIAMBERARDINO
Alessandro DI GIORGIO (up to September 2014)
Marco FRATARCANGELI (up to September 2014)
Giorgio GRISETTI
Daniela IACOVIELLO
Domenico LEMBO
Giorgio MATTEUCCI
Massimo MECELLA
Carlo Maria MEDAGLIA (up to November 2014)
Fabio NONINO
Fabio PATRIZI (up to September 2014)
Antonio PIETRABISSA
Alberto PRETTO
Leonardo QUERZONI
Domenico Fabio SAVO (from March 2014)
Roberta SESTINI
Stravros VASSOS
Marilena VENDITTELLI
Andrea VITALETTI

Post Doc research associates (assegnisti di ricerca)

Marek ADAMCZYK
Sanchez ARMENDARIZ
Emanuele BASTIANELLI
Camillo CARLINI
Mario CARUSO
Massimo CEFALO
Claudio CICCOTELLI
Chiara CONTI
Fabrizio COSSU
Tiziana D'ALFONSO
Antonella DEL POZZO
Maurilio DI CICCO
Alessandro DI GIORGIO
Giuseppe DI LUNA
Fabrizio FLACCO
Vincenzo FORTE
Guido Emanuele FUSCO
Ettore IACOMUSSI
Francesco LEOTTA
Mariano LEVA
Lorenzo LEPORE
Andrea MARRELLA
Matteo MENNA
José MORA
Guido ODDI
Alessandro PELLEGRINI
Andrea PENNISI
Fabio PREVITALI
Stefano PUGLIA
Marco RUZZI
Simone SAGRATELLA
Valerio SANTARELLI
Francesca SCHETTINI
Jlenia TOPPI
Georgios TSAPLES
Claudia VOLPETTI

Research assistants

Arianna BERTOLAZZO
Silvia CANALE
Jacopo CAPOLICCHIO
Cinzia CATINELLA
Federico CIMORELLI
Luana COLIA
Marco CONSOLE
Federico FERRI
Andrea FIASCHETTI
Zoe FRAGOULOPOULOU
Raffaele GAMBUTI
Angelo GENTILI
Cecilia LALATTA COSTERBOSA
Ester LATINI
Francesco LIBERATI
Donato MACONE
Laura MALEY
Silvano MIGNANTI
Valsamis NTOUSKOS
Vincenzo PASCALE
Nicoletta RICCIO
Francesco RINALDI
Valerio SANTELLI
Vincenzo SURACI
Roberto TINO
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

Andrea DORI
Luciano GRANDI
Marcello PANI
Tiziana TONI

Auxiliary services

Antonio SIMEONI

Library

Roberta PROIETTI SEMPRONI
Antonietta ZUCCONI

2.4 Doctoral Programs

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

Bioengineering

DIAG participates in the PhD program in Bioengineering coordinated by the Department DEIS of the University of Bologna.
The research topics are: modeling of biomedical systems, processing of biomedical data, signals and images, biomedical instrumentation, medical informatics, biomechanics, prostheses, and bio-materials.

PhD students (working at DIAG)

XXVIII course	XXIX course
Elena PREVITI	Gianluca BORGHINI
	Manuela PETTI

PhD theses completed in 2014

Pietro ARICÓ
Mental states monitoring through passive Brain-Computer Interface systems
Advisor: Serenella SALINARI

Francesca SCHETTINI
Brain-Computer interfaces for augmented communication: asynchronous and adaptive algorithms and evaluation with end users
Advisor: Serenella SALINARI

Engineering in Computer Science

The council of professors of the PhD program in Engineering in Computer Science is coordinated by Daniele NARDI.
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

XXVII course	XXVIII course	XXIX course
Giuseppe Antonio DI LUNA	Nadine ABU RUMMAN	Maurilio DI CICCO
Bruno CAFARO	Marek ADAMCZYK	Mohammad ABU SNOBER
Mario CARUSO	Noor ALDEEN KAMEL	Davide AVERSA
Cristina CIVILI	Marco ANGELINI	Roberto CAPOBIANCO
Riccardo COLINI BALDESCHI	Reem ATASSI	Claudio CICCOTELLI
Nguyen DUC THIEN	Taigo Maria BONANNI	Antonella DEL POZZO
Francesco FICAROLA	Daniele CONO D'ELIA	Martina DETURRES
Andrea PENNISI	Marco CONSOLE	Federico FERRI
Valerio SANTARELLI	Angela DI IORIO	Matteo MENNA
	Adriano FAZZONE	Mario PAOLI
	Giulia FISCON	Jacopo SERAFIN
	Guglielmo GEMIGNANI	Mara SORELLA
	Lorenzo LEPORE	Annalisa TERRACINA
	Maryam MOUSAVI IRAEI	Mohammad Salah UDDIN
	Valsamis NTOUSKOS	Alessio VAUDI
	Fabio PETRONI	
	Fabio PREVITALI	

XXX course
Valentina FRANZONI
Manuel Alejandro RUIZ GARCIA
Federico LOMBARDI
Federico NARDI
Francesco RICCIO
Daniele UCCI
Andrea VANZO

PhD thesis completed in 2014

Ida MELE
Web Usage Mining and its Applicationsto Web Search and Recommendation
Advisor: Stefano LEONARDI

Mario GIANNI
Multilayered cognitive control for Unmanned Ground Vehicles
Advisor: Fiora PIRRI

Leonardo ANIELLO
Timely Processing of Big Data in Collaborative Large-Scale Distributed Systems
Advisor: Roberto BALDONI

Khalil MASSRI
Data Delivery in Delay Tolerant Networks
Advisor: Andrea VITALETTI

Francesco LEOTTA
Instrumenting and Mining Smart Spaces
Advisor: Massimo MECELLA

Alessandro PELLEGRINI
Techniques for Transparent Parallelization of Discrete Event Simulation Models
Advisor: Francesco QUAGLIA

Sebastiano PELUSO
Efficient Protocols for Replicated Transactional Systems
Advisor: Francesco QUAGLIA

Diego RUGHETTI
Autonomic Concurrency Regulation in Software Transactional Memories
Advisor: Bruno CICIANI

Alessandro RUSSO
Models and Architectures for Dynamic Processes: from Activitycentric to Data-centric Operational Support
Advisor: Massimo MECELLA

Suzanne VAN DER STER
Approximate feasibility in real-time scheduling: Speeding up in order to meet deadlines
Advisor: Alberto MARCHETTI SPACCAMELA

Automatica, Bioengineering and Operations Research

The council of professors of the PhD program in Automatica, Bioengineering 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 now three curricula: "Automatica", "Bioengineering", "Operations Research". 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)

XXVII course

Automatica
Francesco LIBERATI
Giovanni MATTEI
Antonio PAOLILLO
Letterio ZUCCARO

Operations Research
Andrea MANNO

XXVIII course

Automatica
Raffaello BONGHI
Federica CONTE
Marco COGNETTI
Claudio Roberto GAZ
Andrea LANNA
Emanuele MAGRINI
Marsilio TURATTI

Operations Research
Jahanbani ADEL
Valentina BRACAGLIA
Umberto DELLE PIANE
Stefania RENZI

XXIX course

Automatica
Laura D'ORSI
Dario Giuseppe FERRIERO
Raffaele GAMBUTI
Valerio MODUGNO

Operations Research
Andrea CRISTOFARI
Luca LABELLARTE

XXX course

Automatica
Gabriele BUONDONNO
Federico CIMORELLI
Federico PATOTA
Lorenzo RICCIARDI CELSI
Marwa Ahmed HASSAN
Matteo MEKHAIL
Giacomo NAPOLI

Bioengineering
Alessandra ANZOLIN
Stefano CASCHERA

Operations Research
Andrea CALICIOTTI
Stefano FOGLIETTA

PhD theses completed in 2014

Automatica

Pietro PELITI
Visual Servoing for Unmanned Aerial Vehicles
Advisor: Giuseppe ORIOLO

Giorgia CHINI
Control strategies for the vehicle routing problem applied to medical emergencies
Advisor: Francesco DELLI PRISCOLI

Andi PALO
Control of Network-Aware Applications and Intelligent Connectivity in Future Internet
Advisor: Francesco DELLI PRISCOLI

Lorenzo ROSA
Vision-based estimation and control for advanced robotic systems
Advisor: Giuseppe ORIOLO

Martina PANFILI
Modelling, Optimization and Control Algorithms for Resource Management Problems in Computer and Communication Networks
Advisor: Francesco DELLI PRISCOLI

Silvia PARIS
Sparsity based detection strategies for faint signals in noise. Application to astrophysical hyperspectral data
Advisor: Salvatore MONACO

2.5 Visiting Scientists and Scholars

DIAG hosts visiting scientists and scholars from all over the world. Here we list the visitors that spent at least one month at DIAG during 2014.

Adrian LEWIS, Cornell University, Ithaca (NY), USA, January-June 2014.

Allan BORODIN, University of Toronto, Canada, May-June 2014.

Henk F. MOED, Elsevier, Amsterdam, The Netherlands, September-October 2014
Ibrahim SHIKDAHER, Tishreen University, Latakia, Siria, September-December 2014

Leopold SIMAR, Center for Operations Research and Econometrics (CORE), Université Catholique de Louvain, Belgium, March-May 2014

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 2014, in chronological order. Also the Workshops organized at DIAG are reported, with the exception of the project meetings.

- January 21, 1st International SYDIC Workshop http://www.systemdynamics.it/-attivita/eventi/153-1st-international-sydic-workshop-on-system-dynamics-for-policy-assessment-strategy-development.html

- January 22, Yair Amir (Johns Hopkins University, USA), Overlay Networks on a Global Scale: Performance, Quality of Service, and Ultimate Resiliency
- February 12, Adrian Lewis (Cornell University, USA), Identifiability, Nonconvexity, and Sparse Optimization Algorithms
- February 28, Edoardo Marcucci (Roma Tre University and CREI), Urban Freight Transport Policies: Joint Account of Non-linear Attribute Effects and Discrete Mixture Heterogeneity
- March 11, Daniel Lee (University of Pennsylvania, USA), Perception, Planning, and Motor Control in Machines vs. Animals
- March 17, Eszter Lukacs (Institute of Electrical and Electronics Engineers (IEEE), USA), Workshop IEEE Digital Library
- March 21, Sergio Currarini (Leicester University, UK), Performance Thresholds and Optimal Risk Taking
- March 27, Alain Berthoz (College de France, France), Simplexity: Simplifying Principles for Brains and Humanoid Robots
- April 4-5, OpenDiag http://open.diag.uniroma1.it/?q=node/20
- April 10, Georgios Yannakakis (University of Malta), Game AI is Dead - Long Live Game AI!
- May 8, Khaled Kilzie, EXP(AI & ROBOTICS)
- May 12, Manuela Veloso (Carnegie Mellon University, USA), Symbiotic Autonomous Mobile Service Robots
- May 15, Vito Trianni (ISTC, CNR, Italy), A Cognitive Design Pattern for Collective Decisions in Distributed Systems
- May 30, Daniele Nicita (FireEye Italy), The New Breed of Cyber Attacks
- June 5-6, Oligo Workshop 2014: Optimal Firm Behaviour and Game-theoretic Models of Competition https://sites.google.com/a/dis.uniroma1.it/oligo-workshop/
- June 10, Adrian Pearce & Chis Ewin (University of Melbourne, Australia), Transforming Situation Calculus Action Theories for Optimised Reasoning
- July 24, Marcos Paul Gerardo Castro (University of Sydney, Australia), Robust Multiple-Sensing-Modality Data Fusion for Reliable Perception
- October 3, Bud Mishra (New York University, USA), Towards Cancer Hybrid Automata

- October 29-30, Il costo standard nei servizi di trasporto pubblico locale su autobus (Director: Giuseppe Catalano)
- November 18, Hector Levesque (University of Toronto, Canada), Probabilistic Reasoning in the Situation Calculus: A Progress Report
- November 18, Gerhard Lakemeyer (RWTH Aachen University, Germany), Sensor Fusion in the Situation Calculus
- November 18, Yongmei Liu (Sun Yatsen University, China), Multi-agent Knowledge and Belief Change in the Situation Calculus
- November 18, Yves Lespérance (York University, Canada), On Rational Agent Programming
- November 18, Sebastian Sardina (RMIT University in Melbourne, Australia), Advanced Intention and Plan Selection for BDI Agent Systems
- November 18, Gerald Steinbauer (Graz University of Technology, Austria), YAGI: An Easy and Lightweighted Action Programming Language for Education and Research
- November 26, euRobotics week 2014: A Future of Robots@DIAG for Everyone http://www.eu-robotics.net/cms/index.php?idart=3110
- December 4, David Thue (Reykjavik University, Iceland), Interactive Storytelling in Videogames
- December 9, Andrew Murray (University of Dayton, USA), Accurately Locating and Tracking the Center of Mass in Humanoids and Humans
- December 9, Hector Levesque (University of Toronto, Canada), On the Science of AI
- December 9, Franz Baader (Dresden University, Germany), A Description Logic Journey
- December 9, Moshe Vardi (Rice University, USA), A Logical Revolution
- December 19, Luigi Nardi (Imperial College, UK), Introducing SLAMBench: A Performance and Accuracy Benchmarking Methodology for SLAM

2.7 Awards and Recognitions

- Aris Anagnostopoulos and Stefano Leonardi: Google Focused Research Awards (along with 4 more co-winners)
- Luigia Carlucci Aiello has been awarded the Distinguished Service Award by the European Coordinating Committee in Artificial Intelligence (ECCAI), 2014.

- Carlo Mannino: AIRO Best Application Paper Award 2014 for the paper L. Lamorgese, C. Mannino, An exact decomposition approach for the real-time Train Dispatching problem, Operations Research, DOI: 10.1287/opre.2014.1327, 2014
- Carlo Mannino, Antonio Sassano: INFORMS Technical Section on Telecommunications Best Paper Award 2014 for the paper F. D'Andreagiovanni, C. Mannino, A. Sassano, GUB Covers and Power-Indexed Formulations for Wireless Network Design, Management Science 59(1):142-156, 2013
- Salvatore Monaco: Highlight lecture award "Non-linear sampled-data control in space applications", 2nd Conference on Dynamics and Control of Space systems, Rome, Italy, March 24-26, 2014.
- Domenico Lembo has been named as "Exceptional guest editors" by the Semantic Web Journal editors in chief for his work on the Special issue of the Semantic Web Journal on Web Reasoning and Rule Systems (together with Wolfgang Faber, University of Huddersfield, UK).

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 € 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 € 372.177, MULTIPLEX - Foundational Research on MULTIlevel comPLEX networks and systems, S. Leonardi, ending 31-10-2016
- FP7-CP € 802.488, OPTIQUE - Scalable End-user Access to Big Data, R. Rosati, ending 31-10-2016
- FP7-CP € 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-People/2009-IIPP € 83.500, MANON - Methods for advanced multi-objective optimization of complex nanoscale circuits, G. Di Pillo, ending September 2014
- FP7-CP € 438.780, ROVINA - Robots for Exploration, Digital Preservation and Visualization of Archeological Sites, G. Grisetti, ending 31-07-2016
- FP7-CSA € 323.675, ROCKIN - Robot Competitions Kick Innovation in Cognitive Systems and Robotics, D. Nardi, ending 31-12-2015
- FP7-CP € 753.968, TRADR - Long-Term Human-Robot Teaming for Robot-Assisted Disaster Response, F. Pirri, ending 31-12-2017
- FP7-CP € 173.575, FI-Core - Future Internet Core, F. Delli Priscoli, ending 30-09-2016
- ARTEMIS € 240.000, nSHIELD - new embedded systems architecture for multi-layer dependable solutions, F. Delli Priscoli, ending 31-08-2014
- CIP € 212.200, VOICE - Virtual Open Incubation Ecosystem, M. Mecella/S. Vassos, ending 28-02-2017
- CIPS € 95.962, CRISADMIN - CRitical Infrastructure Simulation of ADvanced Models on Interconnected Networks resilience, R. Baldoni, ending 31-08-2014
- ERC-STG € 332.200, PAAl — Practical approximation algorithms, S. Leonardi, ending 30-11-2014

Contracts with Italian Institutions

- 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
- CHIST-ERA € 357.570, ALOOF - Autonomous Learning of the Meaning of Objects, B. Caputo, ending 30-09-2017
- CHIST-ERA € 343.000, COACHES - Cooperative Autonomous robots in Complex and Humans EnvironmentS , L. Iocchi, ending 30-09-2017

Contracts with Companies

- SILICONDEV SRL € 30.000 Esecuzione di una ricerca nell'ambito del progetto: Business Simulation for Healtcare - BuS-4H RIF. FILAS-CR-2011-1137, M. Roma, ending 15-04-2014

- ENEL SERVIZI SRL € 19.000 Studio/ricerca: Servizio di Utility Of The Future presso l'università La Sapienza - Contratto n. 1400055612, A. Nastasi, ending 19-01-2014

- CIVIT € 10.000 Contratto per prestazione professionale: Attività di esperto in materia di analisi dell'evoluzione del contesto economico finanziario ed approfondimento delle tematiche connesse alla valutazione della performance organizzativa ai fini della redazione della relazione sulla performance e la relazione 2012, G. Catalano, ending 31-12-2013

- TELECOM ITALIA SPA € 249.855 Sviluppo di una ontologia e mapping tra ontologia e sorgenti di dati (Ricerca nell'ambito di un progetto che ha come scopo lo sviluppo di una ontologia relativa ai concetti di interesse per la propria funzione organizzativa Open Access), M. Lenzerini, ending 15-06-2014

- DUEL SPA € 57.500 Esecuzione di una ricerca concernente l'analisi di dati del traffico per applicazioni di info-mobilità nell'ambito del progetto FILAS SpA(prot. 0012578 del 21/10/2013 RS/MT PEC), L. Iocchi, ending 23-01-2015

- SMARTCARE SRL € 90.000 Attività di ricerca sul tema: Sviluppo dell'ontologia del debito pubblico e mapping tra ontologia e sorgenti di dati, M. Lenzerini, ending 31-03-2014

- GS AUTOMATION SPA € 32.000 Attività di ricerca riguardante lo sviluppo del sistema: DATA ANALYZER & ACQUISITION SYSTEM - Avviso pubblico Progetti di R&S in collaborazione, da parte delle PMI del Lazio di cui al POR FESR Lazio 2007/2013 ASSE I-Attività 1- Prot. FILAS-CR-2011-1372 CUP F85C13001220007, A. Pietrabissa, ending 30-06-2015

- THALES ALENIA SPACE ITALIA SPA € 14.040 Attività di ricerca relative alla: Realizzazione del Segmento Terrestre per il programma ATHENA-FIDUS nell'ambito del CT pubblico 10109 28/12/2011 tra TAS e Ministero Difesa, F. Delli Priscoli, ending 17-06-2014

- PROMETEO GROUP SRL € 15.000 Integrazione con il sistema informativo di Laboratorio (LIS) dell'IRCCS San Raffaele Pisana ed altra strtuttura. Individuazione e descrizione delle tecniche utili alla costruzione dei componenti di un sistema istema basato sulla codifica SPREC, U. Nanni, ending 31-5-2014

- SO.TEL SRL € 15.000 Attività di studio e sviluppo sperimentale nell'ambito del progetto SMART RETAIL sul tema "Algoritmi per la valutazione del valore commerciale degli scaffali all'interno di spazi commerciali" CORESEARCH POR FESR 20072013 - Prot. FILAS CR 20111068, M. Mecella, ending 31-5-2014

- ACI INFORMATICA SPA € 65.000 Integrazione dei dati basata su ontologie nel dominio della fiscalitá dell'auto, M. Lenzerini, ending 31-12-2014

- CONTRAM MOBILITA' S.C.P.A. € 10.000 Esecuzione di una ricerca nell'ambito del progetto "Contram mobilitá ed i costi standard del TPL nella provincia di Macerata", G. Catalano, ending 30-06-2014

- OLOMEDIA SRL € 7.592 Esecuzione di una ricerca sul tema "Analisi dei punti e delle modalità di innesto di sensoristica RFID e di punti di riscontro", U. Nanni, ending 21-03-2014

- NEXSE SRL € 14.208 Esecuzione di una ricerca sul tema "Modalità di con nessione con i laboratori dedicati all'analisi genetica con l'integrazione di dati", U. Nanni 21-03-2014

- SOLCO SRL € 72.000 Attività di Ricerca nell'ambito del Progetto "COMDIG" - Comunicazione e marketing digitale 3.0, M. Temperini, ending 04-05-2015

- THALES ALENIA SPACE ITALIA SPA € 75.500 Attività di Ricerca nell'ambito di una collaborazione sul tema "Studi Innovativi di Missione e di Rete di nuova generazione" - Programma di Studio SIPROSAT CAP2, F. Delli Priscoli, ending 08-05-2015

- CINECA € 30.000 Analisi delle esperienze delle Università Statali e non, che stanno adottando la contabilità Economico Patrimoniale. Individuazione delle principali difficoltà o problematiche; metodiche o procedimenti per la oro risoluzione o mitigazione, G. Catalano, ending 31-05-2015

- FONDAZIONE CEUR € 10.000 Esecuzione di una ricerca concernente il calcolo del costo medio per uno studente ospitato all'interno delle strutture a gestione pubblica adibite all'ospitalità e formazione di studenti universitari, G. Catalano, ending 15-06-2014

- DIPARTIMENTO DI MECCANICA, MATEMATICA E MANAGEMENT DEL POLITECNICO DI BARI € 20.000 Consulenza di Studio e Ricerca per "Indicatori di performance di una smart city e governance energetica della città", C. Leporelli e R. M. D'Angelico, ending 04-01-2015

- SISTEMI SOFTWARE INTEGRATI SPA € 33.750 Attività di studio e ricerca per il Progettto BEE SAFE nell'ambito del Contratto SSI-AQ-019/2011, D. Nardi, ending 31-12-2014

- THE GAME COMPANY SRL € 10.000 Esecuzione del Progetto "THE GAME COMPANY", S. Leonardi e L. Becchetti, ending 31-12-2014

- FEDERLAVORO E SERVIZI CONFCOOPERATIVE € 30.000 Esecuzione di una ricerca concernente "Il procurement degli enti locali nell'ambito del processo di riforma istituzionale: aspetti metodologici e ipotesi applicative", G. Catalano, ending 03-03-2015

- THALES ALENIA SPACE ITALIA SPA € 22.640 Attività di Ricerca nell'ambito di una collaborazione sul tema "Studio e Definizione di Tecniche di Gestione Sistemi SatCom" e Realizzazione del Segmento Terrestre per il Programma "ATHENA-FIDUS" - CT 1520044824, F. Delli Priscoli, ending 05-06-2015
- SISTEMI & AUTOMAZIONE SRL € 86.000 Attività di Studio e Sviluppo Sperimentale nell'ambito del progetto "SWDISCOVERY" Sviluppo di componenti software, architetture hardware ed identificazione degli algoritmi di social network analisys per analisi di intelligence su grandi quantità di dati, S. Salinari, ending 30-06-2015
- MINISTERO DELLE INFRASTRUTTURE E DEI TRASPORTI € 39.000 Attività di Studio e Ricerca per la definizione dei costi standard dei servizi di trasporto pubblico locale e regionale nonché i criteri per l'aggiornamento e l'applicazione degli stessi, G. Catalano, ending 20-04-2015
- ACI INFORMATICA SPA € 65.000 Integrazione dei dati basata su ontologie nel dominio della fiscalitá dell'auto, M. Lenzerini, ending 31-03-2015
- I.R.S.E.F. LAZIO "Istituto di Ricerca e Studi sull'Educazione e sulla Famiglia" € 13.608 Processo di valutazione sui corsi accreditati dall'INPS ad IRSEF Lazio nel quadro dell'iniziativa "Homo Sapiens Sapiens", U. Nanni, ending 31-12-2014
- FONDAZIONE NEURONE ONLUS PER LO STUDIO E LA RICERCA IN NEUROPSICOBIOLOGIA € 8.000 Esecuzione del collaudo dell'attrezzatura di ricerca "Sistemi ad hoc completo per il controllo di un arto robotico mediante utilizzo di segnali cerebrali", F. Cincotti, ending 31-12-2014

Research Agreements (Convenzioni)

- ADF Service srl, ending 14-10-2015
- ASSOCIAZIONE NAZIONALE AUTOTRASPORTO VIAGGIATORI "ANAV", ending 10-12-2015
- ASSTRA - ASSOCIAZIONE TRASPORTI, ending 15-07-2015
- BRAINSIGNS SRL, ending 14-06-2014
- CESOP Communication srl, ending 30-06-2015
- CINI Consorzio Interuniversitario Nazionale per l'Informatica, ending 27-04-2017
- CLUB DIRIGENTI TECNOLOGIE DELL'INFORMAZIONE DI ROMA - CDTI, ending 02-04-2017
- FEDERLAVORO E SERVIZI CONF-COOPERATIVE, ending 10-07-2015
- FONDAZIONE S.LUCIA, ending 27-07-2015

- FONDAZIONE S.LUCIA (Borsa dottorato), ending 30-09-2017
- FONDAZIONE S.LUCIA (Collaborazione scientifica), ending 13-10-2019
- GOOGLE IRELAND, ending 24-04-2015
- ISTITUTO AFFARI INTERNAZIONALI - IAI, ending 09-09-2016
- KPMG SPA, ending 15-12-2016
- NTT DATA ITALIA SPA, ending 15-12-2017
- ROMA SERVIZI PER LA MOBILITA' SRL, ending 16-04-2016
- SOCIETA' UP SRL, ending 29-05-2017
- TEXAS ENGNEERING EXPERIMENT STATION, ending 15-10-2015
- TRENITALIA SPA, ending 26-11-2015
- UNIVERSITA' DEGLI STUDI DI UDINE, ending 30-07-2015

3 Research

3.1 Algorithm Design and Engineering

Research lines:

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

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

PhD Students: Daniele Cono D'Elia.

Post Docs: Andrea Ribichini, Emanuele Fusco.

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. n 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 analying and optimizing software systems;
- External Memory and Streaming Algorithms for Massive Data Processing: external-memory and streaming algorithms for very large graph problems;
- Incremental Algorithms and Dynamic Data Structures: incremental algorithms for path problems in graphs;
- Approximation and On-line Algorithms: scheduling algorithms, algorithms for metabolic networks, vehicle routing, approximation algorithms for rent-or-buy network design problems, on-line algorithms for stochastic optimization problems such as Steiner tree and set cover under several models;
- Algorithmic Game Theory: quality of strong equilibria in network formation games under restricted communication model;
- Algorithmic approaches for bioinformatics and elearning: application of algorithmic models and techniques to bioinformatics and elearning.

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

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

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

Projects:

- *AMANDA: Algorithmics for MAssive and Networked DAta* - February 2013, February 2017 - PRIN MIUR
- *EUSACOU* - January 2010, July 2014 - UE IRSES project

Journals

[1] Coppa E., Demetrescu C., Finocchi I., Input-sensitive profiling, *IEEE Trans. Software Eng.*, 40(12):1185–1205, 2014.

[2] Demetrescu C., Finocchi I., Ribichini A., Reactive imperative programming with dataflow constraints, *ACM Trans. Program. Lang. Syst.*, 37(1):3, 2014.

[3] Boldi P., Leonardi S., Mascolo C., Vazirgiannis M., Web and social graph mining, *IEEE Internet Computing*, 18(5):9–10, 2014.

[4] Grandoni F., Krysta P., Leonardi S., Ventre C., Utilitarian mechanism design for multiobjective optimization, *SIAM J. Comput.*, 43(4):1263–1290, 2014.

[5] Milreu P., Klein C., Cottret L., Acuña V., Birmelé E., Borassi M., Junot C., Marchetti-Spaccamela A., Marino A., Stougie L., Jourdan F., Crescenzi P., Lacroix V., Sagot M.F., Telling metabolic stories to explore metabolomics data: a case study on the yeast response to cadmium exposure, *Bioinformatics*, 30(1):61–70, 2014.

Conference proceedings

[6] Anagnostopoulos A., Grandoni F., Leonardi S., Wiese A., A mazing 2+eps approximation for unsplittable flow on a path, In Chandra Chekuri, editor, *Proceedings of the Twenty-Fifth Annual ACM-SIAM Symposium on Discrete Algorithms, SODA 2014, Portland, Oregon, USA, January 5-7, 2014*, pages 26–41. SIAM, 2014.

[7] Baldoni R., d'Amore F., Mecella M., Ucci D., A software architecture for progressive scanning of on-line communities, In *34th International Conference on Distributed Computing Systems Workshops (ICDCS 2014 Workshops), Madrid, Spain, June 30 - July 3, 2014*, pages 207–212. IEEE, 2014.

[8] Colini-Baldeschi R., Leonardi S., Sankowski P., Zhang Q., Revenue maximizing envy-free fixed-price auctions with budgets, In Tie-Yan Liu, Qi Qi, and Yinyu Ye, editors, *Web and Internet Economics - 10th International Conference, WINE 2014, Beijing, China, December 14-17, 2014. Proceedings*, volume 8877 of *Lecture Notes in Computer Science*, pages 233–246. Springer, 2014.

[9] Coppa E., Demetrescu C., Finocchi I., Marotta R., Estimating the empirical cost function of routines with dynamic workloads, In David R. Kaeli and Tipp Moseley, editors, *12th Annual IEEE/ACM International Symposium on Code Generation and Optimization, CGO '14, Orlando, FL, USA, February 15-19, 2014*, page 230. ACM, 2014.

[10] Correa J., Marchetti-Spaccamela A., Matuschke J., Stougie L., Svensson O., Verdugo V., Verschae J., Strong LP formulations for scheduling splittable jobs on unrelated machines, In Jon Lee and Jens Vygen, editors, *Integer Programming and Combinatorial Optimization - 17th International Conference, IPCO 2014, Bonn, Germany, June 23-25, 2014. Proceedings*, volume 8494 of *Lecture Notes in Computer Science*, pages 249–260. Springer, 2014.

[11] Epasto A., Feldman J., Lattanzi S., Leonardi S., Mirrokni V., Reduce and aggregate: similarity ranking in multi-categorical bipartite graphs, In Chin-Wan Chung, Andrei Z. Broder, Kyuseok Shim, and Torsten Suel, editors, *23rd International World Wide Web Conference, WWW '14, Seoul, Republic of Korea, April 7-11, 2014*, pages 349–360. ACM, 2014.

[12] Feuerstein E., Marchetti-Spaccamela A., Schalekamp F., Sitters R., van der Ster S., Stougie L., van Zuylen A., Scheduling over scenarios on two machines, In Zhipeng Cai, Alex Zelikovsky, and Anu G. Bourgeois, editors, *Computing and Combinatorics - 20th International Conference, COCOON 2014, Atlanta, GA, USA, August 4-6, 2014. Proceedings*, volume 8591 of *Lecture Notes in Computer Science*, pages 559–571. Springer, 2014.

[13] Lattanzi S., Leonardi S., Efficient computation of the weighted clustering coefficient, In Anthony Bonato, Fan Chung Graham, and Pawel Pralat, editors, *Algorithms and Models for the Web Graph - 11th International Workshop, WAW 2014, Beijing, China, December 17-18, 2014, Proceedings*, volume 8882 of *Lecture Notes in Computer Science*, pages 34–46. Springer, 2014.

[14] Laura L., Nanni U., Temperini M., The organization of large-scale repositories of learning objects with directed hypergraphs, In Yiwei Cao, Terje Väljataga, Jeff K. T. Tang, Howard Leung, and Mart Laanpere, editors, *New Horizons in Web Based Learning - ICWL 2014 International Workshops, SPeL, PRASAE, IWMPL, OBIE, and KMEL, FET, Tallinn, Estonia, August 14-17, 2014, Revised Selected Papers*, volume 8699 of *Lecture Notes in Computer Science*, pages 23–33. Springer, 2014.

[15] Laura L., Nanni U., Temperini M., Visual analysis based on dominator trees with application to personalized elearning, In Elvira Popescu, Rynson W. H. Lau, Kai Pata, Howard Leung, and Mart Laanpere, editors, *Advances in Web-Based Learning - ICWL 2014 - 13th International Conference, Tallinn, Estonia, August 14-17, 2014. Proceedings*, volume 8613 of *Lecture Notes in Computer Science*, pages 207–212. Springer, 2014.

[16] Rozenshtein P., Anagnostopoulos A., Gionis A., Tatti N., Event detection in activity networks, In Sofus A. Macskassy, Claudia Perlich, Jure Leskovec, Wei Wang, and

Rayid Ghani, editors, *The 20th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining, KDD '14, New York, NY, USA - August 24 - 27, 2014*, pages 1176–1185. ACM, 2014.

[17] Tolosa G., Becchetti L., Feuerstein E., Marchetti-Spaccamela A., Performance improvements for search systems using an integrated cache of lists+intersections, In Edleno Silva de Moura and Maxime Crochemore, editors, *String Processing and Information Retrieval - 21st International Symposium, SPIRE 2014, Ouro Preto, Brazil, October 20-22, 2014. Proceedings*, volume 8799 of *Lecture Notes in Computer Science*, pages 227–235. Springer, 2014.

3.2 Artificial Intelligence and Knowledge Representation

Research lines:

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

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

PhD Students: Roberto Capobianco, Cristina Civili, Marco Console, Guglielmo Gemignani, Lorenzo Lepore, Valerio Santarelli, Andrea Vanzo.

Post Docs: José Mora.

Other Collaborators: Emanuele Bastianelli.

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

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

Reasoning about Actions concerns the theory and the implementation of agents that reason, act and perceive in changing, incompletely known, and unpredictable environments. Such agents must have higher level cognitive functions that involve reasoning, for example, about goals, actions, when to perceive and what to look for, the cognitive states of other agents, time, collaborative task execution, etc. Our research on Reasoning about

Actions focuses on several aspects, including: foundations of theory of actions; various forms of planning for sophisticated dynamic properties, e.g., expressed in LTL; high-level agent programs, like ConGolog based on the Situation Calculus; agent behavior synthesis and composition. This research is also related with, and applied to, other areas, such as cognitive robotics, multi-agent/multi-robot systems, software service modeling, execution and composition, high-level programs over ontologies and data sources.

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

Another research line developed in this group tagets 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:

- Luigia Carlucci Aiello has been a member of the evaluation committee for the Kurt Gödel Research Prize Fellowship awarded by the Gödel Foundation, 2014.
- Giuseppe De Giacomo, Editorial Board Member of Artificial Intelligence, Elsevier.
- Giuseppe De Giacomo, Associate Editor of Journal of Artificial Intelligence Research (JAIR).
- Giuseppe De Giacomo, Steering Committee Member of the International Conference on Principles of Knowledge Representation and Reasoning (KR).
- Giuseppe De Giacomo has been the Program Chair of the 14th International Conference on Principles of Knowledge Representation and Reasoning (KR 14), Vienna, Austria, July 20-24, 2014.
- Giuseppe De Giacomo has been a Fellow Committee Member of the European Coordinating Committee for Artificial Intelligence, 2014.

- Giuseppe De Giacomo, "Verification of Data-Aware Processes", invited talk at the 11th International Workshop on Web Services and Formal Methods: Formal Aspects of Service-Oriented and Cloud Computing (WS-FM:FASOCC 2014), held in Eindhoven, The Netherlands, July 30, 2014.
- Giuseppe De Giacomo, "Reasoning About Data and Knowledge-Aware Processes", invited talk at the 21th European Conference on Artificial Intelligence (ECAI 2014), held in Prague, Czech Republic, August 20, 2014.
- Giuseppe De Giacomo has been reviewer for the European Research Council.
- Giuseppe De Giacomo has been a member of the program committee (Journal Track) of the 24th International Conference on Automated Planning and Scheduling, held in Portsmouth, USA, June 21-26, 2014.
- Giuseppe De Giacomo has been a reviewer for the Netherlands Organisation for Scientific Research (NWO) Vici grant under the Innovational Research Incentives Scheme.
- Maurizio Lenzerini, Area Editor of Information Systems - An International Journal for the area of Data Modeling and Knowledge Representation and Reasoning Techniques.
- Maurizio Lenzerini, Area Editor of Journal of Applied Logic for the area of Logic for Knowledge Representation and the Semantic Web.
- Fabio Patrizi, Associate Editor of the Computing Journal, Springer.
- Riccardo Rosati has been co-chair of the 27th International Workshop on Description Logics (DL 2014), Vienna, Austria, July 17-20, 2014.
- Riccardo Rosati has been invited tutorialist at the 14th International Conference on the Principles of Knowledge Representation and Reasoning, (KR 2014) Vienna, Austria, July 20-24, 2014.
- Riccardo Rosati has been invited speaker at the 29th Italian Conference on Computational Logic (CILC 2014), Torino, Italy, June 16-18, 2014.
- Stavros Vassos has been co-chair/co-organizer of Special session "Game Artificial Intelligence" at the 8th Hellenic Conference on Artificial Intelligence (SETN'14).
- Stavros Vassos has been co-chair/co-organizer of Special session "Action Languages" at the 8th Hellenic Conference on Artificial Intelligence (SETN'14).

Projects:

- *OPTIQUE* - Scalable End-User Access to Big Data (EU FP7). November 2012 - October 2016. Riccardo Rosati.

- *Joint project with Smartcare S.r.l.*: Modellazione ontologica per il sistema informativo del debito pubblico. September 2013 - March 2014. Maurizio Lenzerini.
- *SPIRITLETS: SPIRITLET–based Smart spaces*, Award Sapienza research project. November 2013 - April 2015.
- *Speaky Acutattile*, Ministero dello Sviluppo Economico (Industria 2015). June 2011 - April 2015. Luigia Carlucci Aiello and Daniele Nardi.

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3.3 Combinatorial Optimization

Research Lines:

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

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

PhD students: 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 besed 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, Universitá 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
- Modelli Robusti di Ottimizzazione Lineare e Intera per Problemi di Data Mining, progetto di ricerca Sapienza, Dec. 2013 - May 2015.

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3.4 Computer Networks and Pervasive Systems

Research lines:

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

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

PhD Students: Francesco Ficarola, Mario Paoli

Post Doc: Ugo Colesanti.

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

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

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

We are also interested in solving complex communications primitives such as service discovery and event-based data diffusion, with the final goal of characterizing sensors networks as a data storage and retrieval. In the future we plan to address security and privacy issues of such networks. In fact the limited available resources requires new techniques and algorithms. We complement our research with experimental work that is based on simulations (using network simulators such as NS2, OMNET++ and Shawn), and on test-beds (e.g. we run a permanent test-bed of wireless sensor network to monitor the ancient roman remains at the basement of DIAG and we have about 600 active tags to collect and analyse the so called proximity graph, namely a graph in which nodes are users and there is a link between two nodes if their are in proximity). We are also interested in experimenting our ideas on smart mobile phones in the context of augmented reality and fully decentralized recommendations.

Recent Projects:

- *PANORAMA: Coordinated Action on Pervasive Adaptation* - February 2008, January 2011 - EU FP7 Coordinated action.
- *FRONTS: Foundations of Adaptive Networked Societies of Tiny Artefacts* - February 2008, January 2011 - EU FP7 IP.
- *AEOLUS: Algorithmic principles for building overlay computers* - September 2006, February 2010 - EU FP6.
- *PharmAID: smart RFID for tracking medicines* - June 2010, December 2012 - EUREKA Eurostars.
- *TETRIS: ervizi innovativi Open Source su TETRA* - December 2010, December 2013 - MIUR PON01_00451.
- *provinciaWSN: estensione della rete WiFI della provincia di Roma per mezzo di reti di sensori wireless* - Progetto Ateneo 2013
- *Nuove tecnologie per le arti* - Progetto Grandi Attrezzature 2014

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prediction of light stimulus from electrophysiological response in plants *Measurement*, Volume 53, July 2014, Pages 101-116, ISSN 0263-2241.

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3.5 Computer Vision, Computer Graphics, and Perception

Research lines:

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

Members: Barbara Caputo, Marco Fratarcangeli (up to August 2014), Luca Iocchi, Fiora Pirri (leader), Marco Schaerf.

PhD Students: Bruno Cafaro, Angela Di Iorio, Federico Ferri, Valentina Franzoni, Manuel Alejandro Ruiz Garcia, Mario Gianni, Matteo Menna, Federico Nardi, Valsamis Ntouskos, Nadine Abu Rumman.

The problem of Human Action Recognition is investigated, in our research work, within Motion Capture sequences. In this context, we investigated methods based on Gaussian Process Latent Variable Models and Alignment Kernels. We propose a new discriminative latent variable model with back-constraints induced by the similarity of the original sequences. We compare the proposed method with methods based on Dynamic Time Warping and with V-GPDS models, which are able to model highly dimensional dynamical systems. Another line of work is to recognize human actions, starting from a 3D

input data sequence, independently from the camera point of view and from the physical aspect of the person under examination. To face this problem, Kernelized Temporal Cut is used for segmenting the sequence and finding cut points among different actions. Then, a spatio-temporal manifold model is used for representing the time series data and a spatio-temporal alignment algorithm is introduced in order to find matches between action segments.

In the field of Object Reconstruction, a new approach is proposed for 3D modeling of articulated objects, specifically animals, using both components and component aspects. A component of an articulated object is defined here to be that part of it, which is only partially deformable. An aspect is defined as a view of the component from a specific vantage point. Aspects are fixed for an object component. Each aspect is modeled from a single image, using an inflation algorithm and the deformation paradigm. Then aspects are blended and merged together to form the whole component.

In the coherence theory of attention, introduced by Rensink, O'Regan, and Clark (2000), a coherence field is defined by a hierarchy of structures supporting the activities taking place across the different stages of visual attention. At the interface between low level and mid-level attention processing stages are the proto-objects; these are generated in parallel and collect features of the scene at specific location and time. These structures fade away if the region is no further attended by attention. This research work aims to build methods to computationally model these structures, on the basis of data collected in dynamic 3D environments via the Gaze Machine, a gaze measurement framework.

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

The aim of the research activities, concerning with the analysis of Synthetic Aperture Radar (SAR) images in X-band, is to classify different zones in peri-urban forestries integrating information from different sources. An integration of image segmentation and machine learning methods is studied to classify different zones of peri-urban forestries (e.g., trees canopies, lawns, water pounds, roads), exploiting the relation between the gray level signal properties of X-band images and the smoothness and roughness of the ground. Camera calibration is a necessary step in order to develop applications that need to establish a relationship between image pixels and real world points. Usually, for non-zooming cameras, the calibration is carried out by using a grid pattern of known dimensions (e.g., a chessboard). However, for cameras with zoom functions, the use of a grid pattern only is not sufficient, because the calibration has to be effective at multiple zoom levels and some features (e.g., corners) could not be detectable. This research activity focuses on developing calibration methods based on novel calibration patterns, specifically designed for zooming cameras.

Learning a visual object category from few samples is a compelling and challenging problem. In several real-world applications collecting many annotated data is costly and not always possible. However a small training set does not allow to cover the high intraclass

variability typical of visual objects. In this condition, machine learning methods provide very few guarantees. This research activity concentrates on discriminative model adaptation algorithms able to proficiently learn a target object with few examples, relying on other previously learned source categories.

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

Modeling cognitive control is a major issue in robot control, and it is about deciding when a task cannot succeed and a new task need to be initiated. These decisions are induced by incoming stimuli alerting of events taking place while the robot is executing its duties. The research work on modeling robot adaptive behaviors, under salient stimuli, exploits the human inspired paradigm of shifting and inhibition, underlying task switching.

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

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

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

Projects:

- *NIFTi - Natural human-robot cooperation in dynamic environments* - 2010, 2014 - EU FP7 IP.
- *Surgical Threads Simulations Based on a Novel Information-Theory Approach* - 2012, 2014 - NPRP5-353 2 138.
- *TRADR - Long-Term Human-Robot Teaming for Robot Assisted Disaster Response* - 2014, 2018 - FP7 ICT 609763.
- *ALOOF - Autonomous Learning of the Meaning of Objects* - 2014, 2017 - ERA-Net CHIST-ERA.

Exhibitions: euRobotics Week (Rome), EXPO21XX (On-line exhibition).

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3.6 Continuous Optimization

Research lines:

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

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

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

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

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

- Exact penalty and augmented Lagrangian methods, still constituting the founding block of many optimization methods and a springboard for many of the studies of the group.

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

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

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

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

commercialize advanced optimization models and methods to be employed in the production and management of goods and services.

Projects:

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

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[2] De Santis M., Lucidi S., and Rinaldi F. Feasibility pump-like heuristics for mixed integer problems. *Discrete Applied Mathematics*, 165:152–167, 2014.

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[16] Daneshmand A., Facchinei F., Kungurtsev V., and Scutari G. Flexible selective parallel algorithms for big data optimization. To appear in *Proc. of the Forty-Eighth Asilomar Conference on Signals, Systems, and Computers*. Nov. 2-5 2014.

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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, Domenico Fabio Savo, Stavros Vassos.
PhD Students: Mario Caruso, Marco Console, Cristina Civili, Francesco Leotta, Lorenzo Lepore, Alessandro Russo, Valerio Santarelli.
Post Docs: Riccardo De Masellis, Andrea Marrella, José Mora, 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 2014, members of the research group have been invited to organize various events, and to deliver keynote speeches at various conferences and workshops. The following is a list of such activities:

- Maurizio Lenzerini, "Logica e informatica", invited lectures at the "Mathesis, la ricerca in matematica" conference, Roma, November 21, 2014.
- Maurizio Lenzerini, Associate Editor of ACM Journal of Data and Information Quality (JDIQ).
- Maurizio Lenzerini, Editorial Board member of the LMCS - Logical Methods in Computer Science, for the areas of Database theory and Logic for knowledge representation. "Logical Methods in Computer Science".
- Maurizio Lenzerini, Editorial Board member of Big Data Research, Elsevier.
- Maurizio Lenzerini, Editorial Board member of Intelligenza Artificiale, The International Journal of the AI*IA.
- Maurizio Lenzerini, ACM SIGMOD Awards Committee member, 2014.

- Maurizio Lenzerini, Executive Committee member of the 2014 ACM Symposium on Principles of Database Systems (PODS), 2014.
- Maurizio Lenzerini, Steering Committee member of the Sistemi Evoluti di Basi di Dati (SEBD) conference.
- Maurizio Lenzerini, Area Chair (Data integration, metadata management, and interpretability) for the 30th International Conference on Data Engineering, IEEE ICDE 2014.
- Massimo Mecella, Workshop Chair of the 7th IEEE International Conference on Service Oriented Computing & Applications (SOCA), 2014.

Projects:

- Research project funded by Sapienza: "MODEUS - Making Open Data Effectively USable", November 2014 - October 2015.
- Project funded by Regione Lazio: "Integrazione semantica di dati e servizi per le aziende in rete", 2011 - 2014.
- UK Engineering and Physical Sciences Research Council (EPSRC) Project EP/I00520X/1 *Trusted Autonomous Systems*, joint with Alessio Lomuscio, Imperial College London, 2010-2015.
- Research project funded by Sapienza: "Efficiency, Effectiveness and Impact of Schools and Universities", November 2013 - October 2014.
- GenData2020 - Data-driven Genomic Computing, MIUR PRIN 2010, February 2013 - January 2016.
- Research project funded by Telecom Italia: "Sviluppo di una ontologia per la rete di accesso e mapping tra ontologia e sorgenti di dati", September 2013 - April 2014.
- Research project funded by SMARTCARE SRL: "Sviluppo dell'ontologia del debito pubblico e mapping tra ontologia e sorgenti di dati", January 2013 - March 2014.
- Research project funded by CREASYS SRL: "Studio e ricerca riguardante metodi e strumenti 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. January 2014 - March 2015.
- Research project funded by Sapienza: "GODAK: Governing and Opening Data and Applications through Knowledge", January 2014 - January 2015.
- Research project funded by ACI SPA: "Progetto di costruzione di una ontologia per la fiscalitá dell'auto", April 2014 - July 2015.
- VOICE - Virtual Open Incubation Ecosystem, September 2014 - August 2017 (EU FP7).

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3.8 Distributed Systems

Research lines:

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

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

PhD Students: Claudio Ciccotelli, Antonella Del Pozzo, Giuseppe Antonio Di Luna, Federico Lombardi, Fabio Petroni, Nicolò Rivetti, Daniele Ucci.

Post Docs: Leonardo Aniello, Luca Montanari.

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, data processing, 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 in several topics including checkpointing, causal and total 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 around the MidLab laboratory and the Research Center of Cyber Intelligence and Information Security (CIS).

MidLab is focussed on 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. In the last

few years MidLab members have also started to pursue new research trends in the area of high-performance stream processing systems and graph-based computations.

The Distributed Systems group is also strongly involved in the activities of the Research Center of Cyber Intelligence and Information Security (CIS). CIS does leadership research in the context of cyber security, information assurance, critical information infrastructure protection, trend prediction, open-source intelligence, cyber physical systems and smart complex systems. Advanced capabilities in cyber intelligence will be indeed essential in the next years due to the pervasiveness of cloud, social computing and mobility technologies, that lower the control that organizations and governments have over systems, infrastructure and data. CIS aims at designing better information security methodologies, threat profiles and at elaborating defense strategies taking into account the economic and legal impact in a unique framework.Research results are applied to real world contexts such as cyberwarfare, fraud detection, stock market stability, detection of tax evasion, monitoring of safe critical activities, early warning systems and smart environments (houses, buildings, cities etc).

Projects:

- *ROMA - Resilience Enhancement of Metropolitan Areas* - May 2015, December 2016 - MIUR Smart Cities.
- *XASMOS* - January 2014, December 2014 - Industrial project with Selex ES.
- *T-NOVA - Network Functions as-a-Service over Virtualised Infrastructures* - January 2014, December 2016 - EU Strep FP7.
- *PANOPTESEC* - November 2013, September 2016 - EU IP FP7.
- *DMI - Digital Market Intelligence* - October 2013, April 2015 - Regional project.
- *TENACE, Protecting National Critical Infrastructures from Cyber Threats* - February 2013, January 2016 - PRIN MIUR.
- *SM4All, Middleware Platform for Pervasive and Immersive Environments For-ALL* - September 2008, August 2011 - EU Strep FP7.
- *SOFIA, Smart Objects For Intelligent Applications* - January 2009, December 2011 - EU IP ARTEMIS.
- *CoMiFin, Communication Middleware for monitoring financial critical infrastructure* (Project managed by CINI - Consorzio Interuniversitario Nazionale per l'Informatica) - September 2009, March 2011 - EU Strep FP7.
- *DOTS-LCCI, Reliable Middleware systems for Critical Infrastructures based on off-the-shelf components* - March 2010, March 2012 - PRIN MIUR.
- *BLEND, Blending Technologies for Ubiquitous Real-Time Data Access* - June 2010, June 2012 - EUREKA Project.

- *GreenerBuildings, 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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[1] Ateniese G., Baldoni R., Bonomi S., and Di Luna G. A. Fault-tolerant oblivious assignment with m slots in synchronous systems. *Journal of Parallel and Distributed Computing*, 74(7):2648–2661, 2014.

[2] Esposito C., Platania M., and Beraldi R. Reliable and Timely Event Notification for Publish/Subscribe Services Over the Internet. *IEEE/ACM Transactions on Networking*, 22(1):230–243, 2014.

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3.9 High Performance and Dependable Computing Systems

Research lines:

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

Members: Bruno Ciciani (leader), Francesco Quaglia.

PhD Students: Alessandro Pellegrini, Sebastiano Peluso, Diego Rughetti.

Post Docs: Pierangelo Di Sanzo, Roberto Palmieri.

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

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

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

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

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

Projects:

- *Transactional Memories: Foundations, Algorithms, Tools, and Applications (EURO-TM)* - fall 2010, fall 2014 - ICT COST Action

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Submitted papers, technical reports and others

[14] Pellegrini A., Vitali R. and Quaglia F., Autonomic State Management for Optimistic Simulation Platforms IEEE Transactions on Parallel and Distributed Systems (TPDS), to appear.

[15] Quaglia F., A Low-Overhead Constant-Time Lowest-Timestamp-First CPU Scheduler for High-Performance Optimistic Simulation Platforms, Simulation Modelling Practice and Theory, to appear.

3.10 Human-Computer Interaction

Research lines:

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

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

PhD Students: Mario Caruso, Annalisa Terracina, Marco Angelini, Alessandro Russo, Francesco Leotta.

Post Docs: Andrea Marrella

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
- *eLF – eLearning Fitness* - January 2011 - March 2014) - EU "Lifelong Learning Programme"

Journals

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Books

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[4] Catarci T., Ferro N., Poggi A. Bridging Between Cultural Heritage Institutions - 9th Italian Research Conference, IRCDL 2013, Rome, Italy, January 31 - February 1, 2013, Revised Selected Papers. Springer, Communications in Computer and Information Science, vol. 385, 2014, 978-3-642-54346-3

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In Proc. 7th Int. Workshop on Social and Personal Computing for Web-Supported Learning Communities, SPeL, for Advances in Web-Based Learning, ICWL 2014. August, 13-16 2014, Tallinn, Estonia. LNCS 8699, Springer, pp. 3–12.

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3.11 Industrial Organization and Management

Research lines:

- Competition, Regulation and Industrial Policy
- Economics and Management of Education and Research
- Economics of Network Industries
- Efficiency and Productivity 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, Flavia Di Costa, Giulia Peruzzi.

PhD Students: Valentina Bracaglia, Federica Di Camillo, Mojtaba Khorram Niaki.

Our research activity, that includes general issues in industrial economics, public policy and management, is performed by three research groups: *Industrial Organization*, *Management* and *Efficiency, Effectiveness and Impact Analysis of Education and Research: methods and applications*. The *Industrial Organization* research group focuses on the following topics:

- *Competition*, regulation, incentives to investments and industrial policy in network industries (with a focus on telecommunications, air transport, rail transport, local public transport and utilities), in the media industry and in the pharmaceutical sector. For this purpose, the group develops and makes use of game theory, cost proxy models, econometrics, and economic models for the evaluation of investments.
- *Productivity and efficiency analysis*, with a focus on the development of parametric and non-parametric methods which can be applied to different fields in Economics and Management.
- *Economics and management of education and research activities*, with a focus on the evaluation of performance, accreditation and funding of education institutions located in the main European countries. For this purpose, the group develops and makes use of efficiency analysis and econometrics.

- *Mechanism design*, with a focus on the analysis and the development of auction procedures for the efficient allocation of scarce resources, characterized by complementarities or substitutability effects, and on the innovation of procurement systems. For this purpose, the group develops and makes use of agent-based simulation models, game theory and mathematical programming.

The *Management* research group focuses on the following topics:

- *Management control systems*, with a focus on the analysis of organizational procedures and the development of a system of indicators. For this purpose, the group develops and makes use of the multi-criteria methodology applied to managerial decision making problems.

- *Operations management*, with a focus on the performance analysis of innovative product/services development models, production system and supply-chains in complex organizations.

- *Green Management and Corporate Sustainability*, with a focus on the integration of environmental sustainability into corporate strategies and the analysis of the success factors of the green product development process.

The group *Efficiency, Effectiveness and Impact Analysis of Education and Research: methods and applications* performs both theoretical and empirical analysis aimed to the formulation of recommendations for public policies. In particular, this research group has focused on the following topics:

- *Efficiency, effectiveness of scientific research and educational system*, with particular reference to: the evaluation of higher education, scientific research, technological innovation and their financing; the development of new bibliometric approaches and indicators to assess the scientific competitiveness at country, regional and local level; the analysis of the market structure of higher education in Italy and in the European countries; the analysis of public funding to the university system in Italy and other major European countries; the development of public policies in education and scientific research;

- *Evaluation of the administrative activities of the university*, with particular reference to: e-procurement policies and services to support student, funding systems for students and interventions for student aid (loans and bonus); effectiveness of scholarships; managerial tools for the management of universities and public research institutions; management control systems and strategic planning of universities; management of students accommodations.

Finally, the group has established scientific collaborations with national and international public institutions and universities; it is part of the European Network of Indicators Designers (ENID), has implemented and implements different collaborations with the National Agency for University and Scientific Research Evaluation (ANVUR), the Ministry of Education, Universities, and Research (MIUR), the European Commission on the

themes of the evaluation of the impact of public policies for higher education and scientific research.

Projects:

- *EBRP Project: Assessing the Scientific Performance of Regions and Countries at Disciplinary level by means of Robust Nonparametric Methods: new indicators to measure regional and national Scientific Competitiveness*, 2012 - 2017 Elsevier.
- *European Tertiary Education Register (ETER), Contract No. EAC-2013-038*- DG Education, August 2013 - July 2015, European Commission.
- *Transatlantic Partnership for Excellence in Engineering (TEE*), action funded by the European Commission, partnership between Sapienza Università di Roma and University of British Columbia, October 2013 - October 2014.
- *Airlines - High Speed Rail cooperation and competition, Research Grant C26N1339HR*, Sapienza Università di Roma, September 2013 - September 2014
- *Efficiency, Effeciveness and Impact of Schools and Universities, Progetto di Ateneo*, Sapienza Università di Roma, 2013 - 2015
- *Intermodality between air transport and high-speed rail: social welfare, environmental externalities and regulation, Research Grant C26A14YJL5*, Sapienza Università di Roma, September 2014 - September 2015

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[8] D'Alfonso T., Nastasi A., Airport-airline interaction: some food for thought., *Transport Reviews*, 34(6), 730-748, 2014.

[9] Daraio C., Simar L., Directional Distances and their Robust versions. Computational and Testing Issues, *European Journal of Operational Research*, 237, 358-369, 2014.

[10] Diana M., Daraio C., A critical review and an integrated set of policy indicators for evaluating the effectiveness of public transport operations, *International Journal of Transport Economics*, XLI, 75-107, 2014.

[11] Iazzolino G., Laise D., Migliano G., Measuring Value Creation: VAIC and EVA, *Journal of Measuring Business Excellence*, 18(1), 8-21, 2014.

[12] Mauleón E., Daraio C., Bordons M., Exploring gender differences in patenting in Spain, *Research Evaluation*, 23 (1), 62-78, 2014.

[13] Matteucci G., Reverberi P., Parallel trade, product quality, and welfare, *Economics letters*, 122, (2), 258-262, 2014.

Articles in books

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[16] Agasisti A., Catalano G., Di Carlo F., Erbacci A., The use of accrual accounting in Italian universities: a technical perspective, *Proceedings of the 37th European Accounting Association Annual Congress*, 1-33, Tallin, Estonia, 21-23 May 2014.

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3.12 Innovation, Internationalization and the 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, Francesca Sanna–Randaccio (leader), Roberta Sestini.

Post Doc: Chiara Conti.

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 and collusive agreements between firms in the presence of nonprofit organizations. These 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, the effects of climate policies on firms' decision to relocate production abroad, the dynamic behaviour of firms' R&D agreements and the role of nonprofit organizations in oligopolistic markets.

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

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

Internationalization, Competitiveness and the Environment In pursuing this line of research we deal with the effects of unilateral environmental policies on firms' decision to relocate production abroad and on their technology transfer activities. In other terms, this research stream addresses the phenomenon of the so-called "carbon leakage", which is a key policy issue both in the EU and the US. We have analyzed this issue first considering a monopoly market structure and then an international oligopoly. Further research

currently carried out in this area incorporates the hypothesis of firms' heterogeneity due to different emissions technologies.

We have also investigated the role played by MNEs in the international technology transfer (ITT) and the implications for the countries involved. An important mechanism for facilitating the international transfer of environmental friendly technologies to developing countries is the so-called Clean Development Mechanism (CDM). We have studied the role of CDM in channelling foreign technology to China. Our econometric analysis confirms that project size and cost, project location, credit buyers and consultants characteristics, as well as technology diffusion are relevant factors in determining the probability to have a foreign supplier of technology in the project.

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

Coalitions, Majorities and the Stability of Industrial Agreements We analyzed a number of coalition stability concepts for the analysis of alliances and agreements within strategic settings. The emphasis was placed on oligopolies in which firms can either act simultaneously or sequentially.

Quality Collusion and Coalitions in Oligopoly We analyse the possibility for firms to form alliances affecting product differentiation and prices in a market with vertically differentiated goods. We model the problem as a three-stage game in which, at the first stage firms are engaged in a sequential game of alliance formation, at the second stage they decide their product variants while, at the third stage, they set prices. It is shown that only intermediate alliance structures arise in equilibrium and, in particular, only those containing the firm that produces the bottom quality variant. Moreover, whoever is the additional player included in an alliance (either the intermediate or the top quality firm), all equilibrium price and quality configurations always coincide with that observed in the case of a duopoly, with a high-quality firm competing against a low-quality rival.

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

Externalities from immigration and effects on innovation We empirically investigate the effect of immigration on innovation, using patent data and firms' self-reported innovation (product, process and organizational) as outcome variable. In the previous literature it is found that high-skilled and low-skilled migrants have opposite effects on innovation. We focus on Italy, and we adopt a very small geographical scale of analysis (NUTS3, corresponding to Italian provinces). Our estimation results show a negative effect of immigrants on Italian provinces' patent applications, while no effect emerges when broader measures of innovation, encompassing both radical and incremental innovation, are considered.

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3.13 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
- Bioengineering for Molecular Biology and Bioinformatics

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

PhD Students: Gianluca Borghini, Federica Conte, Manuela Petti, Elena Previti, Alessandra Anzolin, Stefano Caschera.

Post Docs: Francesca Schettini, Jlenia Toppi.

The research activity in this area concerns with the applications of the general methodologies of modelling, estimation and optimal control theory to the study of biomedical and biological systems. Researches on biomedical applications were performed since the early 70's with regard to biomechanics, prostheses and modelling of cellular growth. At present, the group is also engaged in a multidisciplinary effort, pursuing a wide range of research topics by developing mathematical methods applied to neurophysiology, to the analysis and integration of omics data, and by designing innovative instrumentation for neurorehabilitation.

The main research topics are:

- Modelling and Identification of tumor response to radiations;
- Analysis and modeling of insulin secretion and glucose metabolism;
- Estimation of cerebral connectivity in humans by means of structural and functional models and applications;
- Design and validation of EEG-based Brain-Computer Interfaces for assistive and rehabilitation purposes;
- Computational modeling and analysis of omics data.

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 (BCI) techniques in the rehabilitation of stroke subjects; the utilization of the neuroengineering tools in the field

of the economy/marketing; the optimization of tumor radiotherapy, the development of computational and bioinformatic tools for the analysis of omics data in different organisms and diseases, including berry developments in plants and human solid tumors.
Many national and international cooperations are actually active as: Dip. di Fisiologia Umana e Farmacologia dell'Università "La Sapienza" (Roma), Istituto di Medicina Interna Università Cattolica - Policlinico A. Gemelli (Roma), Istituto di Analisi dei Sistemi e Informatica (IASI) – CNR (Roma), Istituto per le applicazioni del calcolo (IAC) – CNR (Roma), Laboratorio di Genetica Agraria, Dipartimento di Biotecnologie, Università di Verona, Dip. di Biotecnologie Cellulari ed Ematologia, Sapienza Université Roma, Laboratorio di Oncogenesi Molecolare, Istituto Nazionale Tumori Regina Elena (Roma), Dpt. of Biomedical and Electrical Engineering - University of South California (USA), ECE Kansas State University (USA), Institut del la Santé et de la Recherche Medicale-Unité 870 Faculté de Medicine Lyon, Conway Institute of Biomolecular and Biomedical Research University College, Dublin, Bariatric and Metabolic Surgery, King's College, London.

Projects:

- *Sviluppo di un dispositivo per la misurazione dell'apprendimento in compiti di guida o di controllo di processi mediante l'acquisizione di dati neurometrici tramite EEG*. Progetto FILAS (Capofila: BrainSigns srl.)

- *Sviluppo e validazione di un'interfaccia cervello-computer per il controllo domotico basata su un paradigma di presentazione rapida e seriale di stimoli visivi.* Progetto di avvio alla ricerca (responsabile: F. Aloise assegnista di ricerca).

- *Sviluppo di metodi e modelli per l'analisi delle reti funzionali cerebrali nell'uomo, loro descrizione mediante teoria dei grafi e loro caratterizzazione per applicazioni biomediche avanzate*. Finanziamento da IRCCS Fondazione Santa Lucia per il cofinanziamento di un posto RTD di tipo A (100000 euro).

- *Convenzione stipulata tra il Dipartimento e la Fondazione Santa Lucia IRCCS per il cofinanziamento di una borsa triennale per il Corso di Dottorato di Automatica, Bioingegneria e Ricerca Operativa, XXX ciclo.* Il contributo della Fondazione è pari ai due terzi della retribuzione lorda totale (euro 32500,48).

- *Brain-to-brain connectivity from simultaneous neuroelectric and autonomic multi-subjects recordings as a new tool to study human social interaction.* Progetto MIUR Futuro in Ricerca.

- *Definition and validation of brain connectivity indices for the evaluation of cortical plasticity induced by neurorehabilitation.* Progetto di Ateneo.

- *Small World Discovery "Sviluppo di componenti software, architetture hardware ed identificazione degli algoritmi di social network analysis per analisi di intelligence su grandi quantità di dati".* Progetto FILAS.

- *To the root of organ growth: the control of root meristem activity in Arabidopsis.* Progetto di Ateneo.

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[14] Brunner C., Blankertz B., Cincotti F., Kübler A., Mattia D., Miralles F., Nijholt A., Otal B., Salomon P., and Müller-Putz G. R. BNCI Horizon 2020 - Towards a roadmap for brain/neural computer interaction., In: *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 8513, 2014.

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3.14 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 Daniele Bloisi, Giorgio Grisetti, Luca Iocchi, Daniele Nardi (leader), Giuseppe Oriolo, Alberto Pretto, Marilena Vendittelli.

PhD Students: Taigo Maria Bonanni, Maurilio Di Cicco, Thien Nguyen-Duc, Andrea Pennisi, Fabio Previtali, Francesco Riccio, Jacopo Serafin.

Other Collaborators: Fabrizio Cossu, Cristiano Gennari.

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.

Several open-source hardware and software components and data sets are released and listed in our Web site `www.diag.uniroma1.it/~labrococo`. They include the design of a small mobile robot MARRtino, the software libraries OpenRDK, Petri Net Plans, IMBS, PHIS, PTracking and data sets for maritime surveillance (MarDT) and soccer robot vision applications (GNAO).

The application domains, where the research ideas have been tested and experimentally evaluated, include virtual agents and multi-robot systems in soccer, search and rescue, surveillance and domotics. Specifically, the problem of sensor fusion and situation awareness has been targeted in the framework of maritime surveillance.

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

robotic platforms available, ranging from NAO humanoid robots by Aldebaran, to mini UAVs deployable in search and rescue operations, to more traditional wheeled platforms.

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

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

- Luca Iocchi has been member of the Board of Trustees of the RoboCup Federation, 2014.
- Daniele Nardi has been President of the RoboCup Federation, 2014.
- Daniele Nardi has been chair of the Robotics Track of the Autonomous Agents and Multi-Agent Systems, 2014.
- The SPQR team of humanoid soccer players obtained the 1st place in Iranian Open, the 3rd place in Geman Open, Magdeburg, and participated in RoboCup 2013, Eindhoven, 2013.
- Domenico Daniele Bloisi has been chair and co-organizer of "WARV 2014, Special Session on Active Robot Vision" at the 9th Joint International Conference on Computer Vision, Imaging, and Computer Graphics Theory and Applications (VISIGRAPP 2014).

Projects:

- *BEESAFE*. December 2011 - March 2015. Sistemi Software Integrati, Daniele Nardi, and Luca Iocchi.
- *Jump traffic Jam (JTJ)*. October 2013 - February 2015. Duel TV, Daniele Nardi and Luca Iocchi.
- *RoCKIn* (EU FP7). January 2013 - December 2015. Daniele Nardi and Luca Iocchi.
- *ROVINA* (EU FP7). February 2013 - January 2016. Giorgio Grisetti and Daniele Nardi.
- *COACHES* (EU Chist-era). October 2014 - September 2017. Luca Iocchi and Daniele Nardi.

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[2] Lima P., Nardi D., Kraetzschmar G., Berghofer J., Matteucci M., and Buchanan G. RoCKIn Innovation Through Robot Competitions. *Robotics Automation Magazine, IEEE*, 21(2), 8-12, 2014.

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[4] Pennisi A., Bloisi D.D., Iocchi L., and Nardi D. Ground Truth Acquisition of Humanoid Soccer Robot Behaviour. *Chapter in RoboCup 2013: Robot World Cup XVII*, 8371, 560-567, 2014.

[5] Bonanni T.M., Grisetti G., and Iocchi L. Merging Partially Consistent Maps. *In Simulation, Modeling, and Programming for Autonomous Robots, Brugali D., Broenink J.F., Kroeger T., and MacDonald B. Editors, Springer International Publishing*, 8810, 352-363, 2014.

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[6] Agarwal P., Grisetti G., Tipaldi G.D., Spinello L., Burgard W., and Stachniss C. Experimental Analysis of Dynamic Covariance Scaling for Robust Map Optimization Under Bad Initial Estimates. *Proc. of the IEEE International Conference on Robotics and Automation (ICRA)*, 2014.

[7] Capobianco R., Gemignani G., Bloisi D.D, Nardi D., and Iocchi L. Automatic Extraction of Structural Representations of Environments. *Proc. of the 13th Intelligent Autonomous System conference (IAS)*, 2014.

[8] Cognetti M., Oriolo G., Peliti P., Rosa L., and Stegagno P. Cooperative control of a heterogeneous multi-robot system based on relative localization. *Proc. 2014 IEEE/RSJ International Conference on Intelligent Robots and Systems*, 350-376, 2014.

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[10] Gemignani G., Nardi D., Capobianco R., Bloisi D.D., and Iocchi L. Interactive Semantic Mapping: Experimental Evaluation. *Proc. Int. Symposium on Experimental Robotics (ISER 2014)*, 2014.

[11] Nardi L. and Iocchi L. Representation and Execution of Social Plans through Human-Robot Collaboration. *Proc. Fifth International Conference on Social Robotics (ICSR 2014)*, 266-275, 2014.

[12] Serafin J. and Grisetti G. Using Augmented Measurements to Improve the Convergence of ICP. *Proc. of the 4th International Conference on Simulation, Modeling and Programming for Autonomous Robots (SIMPAR 2014)*, 2014.

3.15 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), Alessandro Di Giorgio, Alberto Isidori (Professor emeritus), Antonio Pietrabissa.

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

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

The networked systems area has developed, in the last 13 years, thanks to the successful participation in 35 major advanced research projects mainly financed by the European Union (EU), carried on together with major European ICT players. The networked systems area supports a Future Internet vision (in particular, the group participates to the large FI-WARE EU project just concerning the Future Internet technology foundation) foreseeing a technology independent distributed framework including coordinated advanced control algorithms (utilizing methodologies such as reinforcement learning for multi-agent systems, data mining, game theory, bounded optimal control, predictive control and robust control). These algorithms, on the basis of homogeneous integrated metadata (deriving from properly selected heterogeneous information related to the present network and user status, converted in metadata and aggregated in a context-aware fashion), take consistent decisions (which are eventually actuated in the networks) concerning the management of network resources and of network contents/services, aiming at maximizing resource exploitation, while satisfying users in terms of Quality of Experience expectations (related to Quality of Service, security, mobility,... requirements). For dealing with the above-mentioned vision, the networked systems area deals with the following key enablers: model-free learning, multi-agents with minimum coordination, cross-layering/cross-network optimization, context awareness, data fusion, decision support systems. In the framework of the in progress projects, the above-mentioned vision has been applied in the following areas: home network speed enhancement up to Gbps, optimization of hybrid ad hoc and satellite networks, resource management for telecommunication and energy distribution networks (smart grids), demand side management for planning electric utilities, smart grids for supporting fully electrical vehicles, content management for peer-to-peer television, protection of critical infrastructures, total airport security, embedded system security/privacy/dependability, remote diagnosis

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

Projects:

- *Cockpit-CI, Cybersecurity on SCADA: risk prediction, analysis and reaction tools for Critical Infrastructures* (managed by CRAT) - April 2012, March 2015 - EU SEC FP7 Project.
- *DAAS, Data Analysis and Acquisition System* - November 2013, March 2015 - Progetto FILAS.Co-research
- *Fi-WARE, Future Internet Core Platform* - May 2011, April 2014 - EU ICT FP7 Project.
- *Fi-CORE* - September 2014, September 2016 - EU ICT FP7 Project.
- *MOBINCITY, Smart Mobility in Smart City* (managed by CRAT) - July 2012, June 2015 - EU FP7 ICT Project
- *nSHIELD, New embedded System arcHItecturE for multi-Layer Dependable solutions* - September 2011, August 2014 - EU ARTEMIS-JU Project
- *PLATINO* - July 2012, June 2015 - Progetto MIUR PON.
- *SMARTV2G, Smart Vehicle to Grid Interface* - June 2011, May 2014 - EU FP7-2011-ICT-GC Project
- *SWIPE, Space WIreless sensor networks for Planetary Exploration* (managed by CRAT) - April 2013, October 2015 - EU SPA FP7 Project.
- *T-NOVA, Network Functions as-a-Service over Virtualized Infrastructures* - January 2014, December 2016 - EU ICT FP7 Project.
- *TASS, Total Airport Security System* - April 2010, March 2014 - EU FP7-2011-ICT-GC Project.

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[2] Di Giorgio A., Liberati F., Near real time load shifting control for residential electricity prosumers under designed and market indexed pricing models, *Applied Energy*, 128, 119-132, 2014.

[3] Di Giorgio A., Liberati F., Canale S., Electric vehicles charging control in a smart grid: A model predictive control approach, *Control Engineering Practice*, 22, 147-162, 2014.

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[5] Battilotti S., Cimorelli F., Delli Priscoli F., Gori Giorgi C., Monaco S., Panfili M., An Approach Based on Reinforcement Learning for Quality of Experience (QoE) Control, *Proceedings of the 18th International Conference on Computers (part of CSCC14)*, Santorini Island, Greece, July 17-21, 2014.

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[10] Delli Priscoli F., Fogliati L., Palo A., Pietrabissa A., Dynamic Class of Service mapping for Quality of Experience control in future networks, *Proceedings of the World Telecommunication Congress (WTC14)*, Berlin (DE), 1-6, June 1-3, 2014

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[21] Chini G., Control strategies for the vehicle routing problem applied to medical emergencies. Tesi di dottorato in Ingegneria dei Sistemi, XXVI ciclo, Aprile 2014.

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[23] Panfili M., Modelling, optimization and control algorithms for resource management problems in computer and communication networks. Tesi di dottorato in Ingegneria dei Sistemi, XXVI ciclo, Aprile 2014.

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[25] Cusmai M., Delli Priscoli F., Lanna A., Palo A., Tamea G., Complex Event Processing and Business Process Integration in a data fusion framework for security applications, submitted to *International Journal of Electronic Security and Digital Forensics*, September 2014.

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3.16 Nonlinear Systems and Control

Research lines:

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

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

PhD Students: Raffaello Bonghi, Giovanni Mattei.

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

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

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

Projects:

- *Totally polymeric ionic transducers: applicability study, performance analysis and prototypical realizations for advanced sensor-actuator devices* - March 2010, December 2012 - MIUR PRIN.
- *SARFIRE* February 2010 - February 2012 - ASI,
- *Visual inspection of a TOKAMAK machine* - 2012, ENEA Project.

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[3] Califano C., Observer Error Linearization Problem via Dynamic Compensation. *IEEE Transactions on Automatic Control*, vol. 59, no. 9, pp. 2502 - 2508, 2014.

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[6] De Persis C., Jensen T.N., Ortega R., Wisniewski R., Output regulation of large-scale hydraulic networks. *IEEE Transactions on Control Systems Technology*, vol. 22, n. 6, pp. 238 - 245, 2014.

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[10] Placidi G., Avola D., Ferrari M., Iacoviello D., Petracca A., Quaresima V., Spezialetti M., A low cost real time virtual system for postural stability assessment at home. *Computer Methods and Program in Biomedicine*, vol. 117, n. 2, pp. 322 - 333, 2014.

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[13] Mattei G. and Monaco S., Nonlinear Autopilot Design for an Asymmetric Missile Using Robust Backstepping Control. *Journal of Guidance, Control, and Dynamics*, vol. 37, pp. 1927-1940, 2014.

[14] Pucci, D., Hamel T., Morin P., and Samson C., Nonlinear Feedback Control of Axisymmetric Aerial Vehicles. *Automatica*, Vol. 53, pp. 72 - 78, 2014.

[15] Boncagni, L., Vitelli R., Carnevale D., Galperti C., Artasersea G., Pucci D., An overview of the software architecture of the plasma position, current and density realtime controller of the FTU. *Fusion Engineering and Design*, Vol. 89, n. 3, pp. 204 - 213, 2014.

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PhD theses

[34] Paris Silvia (Doppio-titolo Docteur en Science de l'Universite de Nice Sophia Antipolis, con borsa francese: tutore italiano A. Ferrari tutore italiano S. Monaco) Dottorato in Ingegneria dei Sistemi XXVI Ciclo Sparsity based detection strategies for faint signals in noise. Application to astrophysical hyperspectral data.

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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: Gabriele Buondonno, Marco Cognetti, Claudio Gaz, Emanuele Magrini, Valerio Modugno, Antonio Paolillo, Federico Patota.

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

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

The main research topics are: nonlinear control of robots; control of manipulators with flexible elements (in particular, with Variable Stiffness Actuation); hybrid force/velocity and impedance control of manipulators interacting with the environment; optimization schemes in kinematically redundant robots; motion planning for high-dimensional systems; motion planning and control of wheeled mobile robots and other nonholonomic mechanical systems; control-based motion planning for mobile manipulators; motion planning and control of locomotion in humanoid robots; stabilization of underactuated robots; control of locomotion platforms for VR immersion; sensor-based navigation and exploration in unknown environments; image-based visual servoing; control and visual servoing for unmanned aerial vehicles (UAV); multi-robot coordination and mutual localization; unsupervised continuous calibration of mobile robots; actuator/sensor fault detection and isolation in robots; safe control of physical human-robot interaction; sensory supervision of human-robot interaction. We also pursue more application-driven research, such as the development of a large team of mobile robots for luggage transport in airports.

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

(Pendubot by Quanser), and several mobile robots, including wheeled (a MagellanPro by iRobot, a team of five Kheperas III by K-Team), legged (a NAO humanoid robot by Aldebaran, 2 quadruped Sony AIBOs), and flying (a Hummingbird and a Pelican quadrotor UAVs by AscTec) platforms. These robots are equipped with sensing devices of various complexity, going from ultrasonic/laser range finders to cameras, Kinect depth sensors, and stereo vision systems. In the past, we have also designed and built a two-link flexible manipulator (FlexArm) and a differentially-driven wheeled mobile robot (SuperMARIO).

Projects:

- *SAPHARI, Safe and Autonomous Physical Human-Aware Robot Interaction* - November 2011–October 2015 - EU FP7 IP (coordinator).
- *I-MULE* - January 2012–December 2014 - Industria 2015: Nuove Tecnologie per il Made in Italy.

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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 Fazzone.

Post Docs: Diodato Ferraioli, Bart de Keijzer

We can group our activities in four main areas: (1) graph-mining algorithms, (2) probabilistic analysis of graphs, (3) scheduling problems, and (4) auctions and game theory.

Regarding graph mining, we have designed sampling techniques for estimation the generalized clustering coefficient, a measure used to measure how connected are users in their circles. Motivated by problems in computational advertising, we designed techniques for finding efficiently in an online way who are the main competitors in a given market segment. And motivated by the fact that our actions are leave traces, either through social media, or through different types of sensors, we developed techniques for discovering automatically events that take place in a city.

The second main line of our research activities has been the application of probabilistic techniques for graph analysis. We studied protocols for arriving into a consensus in a network that is equal to the majority of the opinions of the network members. We also studied stochastic-probing models for matroids; for instance, in online matching problems in may not be known whether two nodes match, unless we try to match them. Thus we would like to find a good matching that minimizes the number of probes. We also looked at other important processes on networks that are being used for the diffusion of products; we studied the dynamics created when competing companies want to use viral-marketing strategies and try to dominate their competitors.

Scheduling problems have a variety of application in diverse fields so we have put efforts to do progress in this area. We have improve the approximation for the problem where we try to maximize number of jobs with deadlines that can be assigned to machines (or people) under maximum capacity constraints. We have looked at message aggregation, ad we have studied about how we can compute a schedule for transporting goods from a supplier to a warehouse suppliers that minimizes shipping and storage costs.

We have also performed a lot of activity in problems on auctions and game theory. We have designed auctions with various desirable properties, such as prior-freeness, in Bayesian settings and envy-freeness. We have designed of mechanisms for allocating items to bidders whose values are unknown, and we have show how we can apply cost-sharing techniques for sharing profits among nodes, such as to maximize the qualities of solutions for the problems that we study.

Finally, our group has engaged in other research activities as well. The project COLITA, which allows to perform offline advertising by exploiting social media, was a finalist at Telecom Italia's Big Data Challenge. We have had results on voting problems, mechanism design for multiobjective optimization, privacy-preserving recommendation systems, and approximation algorithms for the fair allocation of indivisible goods, to name a few.

Projects:

- *Web Algorithmics for Large-Scale Data Analysis*, Google Focused Research Award, 2014–current.
- *MULTIPLEX: Foundational Research on MULTIlevel comPLEX networks and systems*, 2012–2015, EU FET, FP7.
- PAAI: Practical Approximation Algorithms, 2010–2014, Associate partner at ERC Starting Grant, FP7.

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