DIAG - Research areas

Biomedical Engineering

Economics

Engineering in Computer Science

Management Engineering
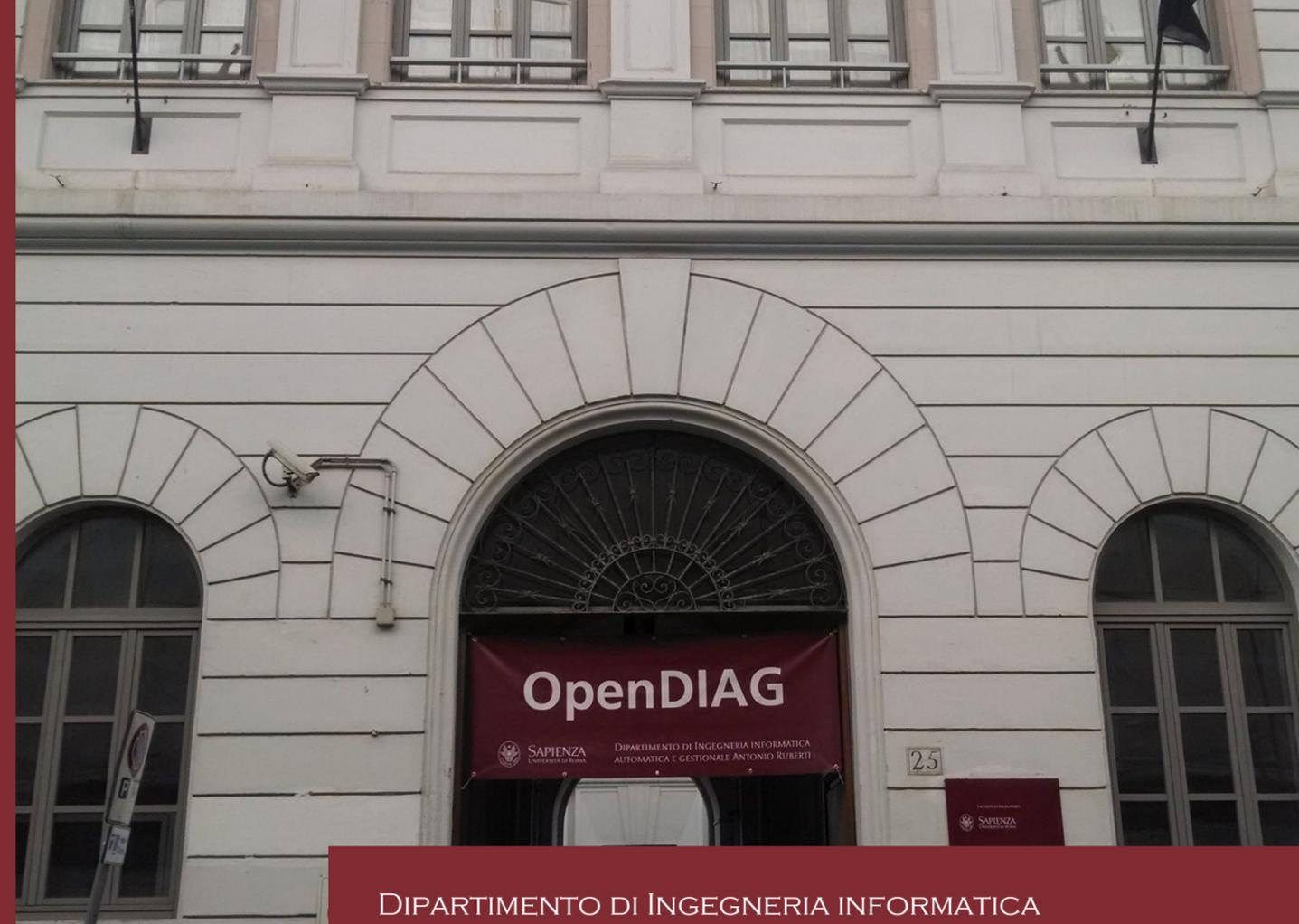
Operations Research

Systems and Control Engineering

Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti

Via Ariosto 25, 00185 Roma

www.diag.uniroma1.it

Research Report 2015   Dipartimento di Ingegneria informatica automatica e gestionale Antonio Ruberti

OpenDIAG

Dipartimento di Ingegneria informatica
automatica e gestionale Antonio Ruberti

Research Report 2015

SAPIENZA
Università di Roma

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

Research report 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 2015.

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 2015 consists of 25 full professors, 29 associate professors, and 17 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 6 research areas, each composed of one or more research groups. This organization is reflected in the structure of Section 3, where all the research groups 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 2015.

2 General Information

2.1 Location

The location of DIAG is the building formerly 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 - Vision, Perception and Learning 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

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.
Co-Heads: Laura ASTOLFI and Febo CINCOTTI

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

Research Center of Cyber Intelligence and Information Security (CIS)
Via Ariosto 25 - wing B1
It is a multidisciplinary center developing new knowledge and operational methodologies to gather relevant information from cyber and physical environments and to transform it through intelligence processes in enriched information that can be used to prevent incidents that can harm the society by creating at the same time smarter complex systems.
Web: `http://www.cis.uniroma1.it/`
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 - COgnitive COoperating RObots Laboratory
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   Venerino FILOSA

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 (up to October 2015)
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

Aris ANAGNOSTOPOULOS (from Sept. 2015)
Alessandro AVENALI
Luca BECCHETTI
Luca BENVENUTI
Barbara CAPUTO
Ioannis CHATZIGIANNAKIS
Febo CINCOTTI (from September 2015)
Fabrizio D'AMORE
Rosa Maria DANGELICO (from October 2015)
Cinzia DARAIO
Camil DEMETRESCU
Alberto DE SANTIS
Lorenzo FARINA

Luca IOCCHI
Domenico LAISE
Leonardo LANARI
Paolo LIBERATORE
Marco Antonio MARINI
Massimo MECELLA (from September 2015)
Fabio NONINO (from September 2015)
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 (up to August 2015)
Laura ASTOLFI
Roberto BERALDI
Domenico Daniele BLOISI (up to August 2015)
Renato BRUNI
Claudia CALIFANO
Febo CINCOTTI (up to August 2015)
Rosa Maria DANGELICO (up to Sept. 2015)
Paolo DI GIAMBERARDINO
Mario GIANNI (from April 2015)
Giorgio GRISETTI
Daniela IACOVIELLO
Domenico LEMBO
Giorgio MATTEUCCI
Massimo MECELLA (up to August 2015)
Fabio NONINO (up to August 2015)
Antonio PIETRABISSA
Alberto PRETTO
Leonardo QUERZONI
Domenico Fabio SAVO
Roberta SESTINI
Stravros VASSOS (up to August 2015)
Marilena VENDITTELLI
Andrea VITALETTI

Post Doc (assegnisti di ricerca) and research assistants

Stefano ARMENIA
Marek ADAMCZYK
Sanchez ARMENDARIZ
Leonardo ANIELLO
Lissette Vanessa ARMENDARIZ SANCHEZ
Emanuele BASTIANELLI
Taigo Maria BONANNI
Gabriella CARAMAGNO
Camillo CARLINI
Mario CARUSO
Massimo CEFALO
Claudio CICCOTELLI
Cristina CIVILI
Ugo Maria COLESANTI
Chiara CONTI
Fabrizio COSSU
Tiziana D'ALFONSO
Antonella DEL POZZO
Bart DE KEIJZER
Rocco DE ROSA
Maurilio DI CICCO
Alessandro DI GIORGIO
Giuseppe DI LUNA
Fabrizio FLACCO
Vincenzo FORTE
Guido Emanuele FUSCO
Ettore IACOMUSSI
IlJa KUZBORSKIJ
Jakub LACKI
Francesco LEOTTA
Mariano LEVA
Lorenzo LEPORE
Andrea MARRELLA
Matteo MENNA
Luca MONTANARI
José MORA
Paolo NAGGAR

Fabrizio NATOLA
Guido ODDI
Martina PANFILI
Patricia NOVI
Alessandro PELLEGRINI
Andrea PENNISI
Fabio PREVITALI
Stefano PUGLIA
Marco RUZZI
Simone SAGRATELLA
Valerio SANTARELLI
Francesca SCHETTINI
Jlenia TOPPI
Georgios TSAPLES
Claudia VOLPETTI
Letterio ZUCCARO

Administration staff

Amelia ARRICALE
Flavia CAGNIZI
Antonietta CANGELLI
Ugo CINELLI
Giuditta FILOMENA (up to June 2015)
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 hosts the PhD programs in *Engineering in Computer Science* and in *Automatica, Bioengineering 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

Engineering in Computer Science

The council of professors of the PhD program in Engineering in Computer Science is co-ordinated 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

XXVIII course	XXIX course
Nadine ABU RUMMAN	Maurilio DI CICCO
Marek ADAMCZYK	Mohammad ABU SNOBER
Noor ALDEEN KAMEL	Davide AVERSA
Marco ANGELINI	Roberto CAPOBIANCO
Reem ATASSI	Claudio CICCOTELLI
Taigo Maria BONANNI	Antonella DEL POZZO
Daniele CONO D'ELIA	Martina DETURRES
Marco CONSOLE	Federico FERRI
Angela DI IORIO	Matteo MENNA
Adriano FAZZONE	Mario PAOLI
Giulia FISCON	Jacopo SERAFIN
Guglielmo GEMIGNANI	Mara SORELLA
Lorenzo LEPORE	Annalisa TERRACINA
Valsamis NTOUSKOS	Mohammad Salah UDDIN
Fabio PETRONI	
Fabio PREVITALI	

XXX course	XXXI course
Valentina FRANZONI	Fabio ANGELETTI
Manuel Alejandro RUIZ GARCIA	Fabio Maria CARLUCCI
Federico LOMBARDI	Davide CINGOLANI
Federico NARDI	Simone ECONOMO
Francesco RICCIO	Marco IMPEROLI
Daniele UCCI	Fabrizio NATOLA
Andrea VANZO	Ciro POTENA
	Marta SANZARI
	Daniele SORA
	Ali YOUSSEF

PhD thesis completed in 2015

Mario CARUSO
Service Ecologies, Energy Management, and Accessibility in Smart Homes
Advisor: Massimo MECELLA

Giuseppe Antonio DI LUNA
On deterministic counting in Anonymous dynamic networks
Advisor: Roberto BALDONI

Francesco FICAROLA
Computing on evolving social networks
Advisor: Andrea VITALETTI

Duc Thien NGUYEN
Using kuka robot for teaching assistant
Advisor: Luca IOCCHI

Andrea PENNISI
Human Behavior Understanding with Multiple Heterogeneous Sensors
Advisor: Luca IOCCHI

Valerio SANTARELLI
Designing Ontology-based Data Access Solutions: Representation and Reasoning Support
Advisor: Domenico LEMBO

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)

XXVIII course	XXIX course	XXX course

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

Operations Research
Jahanbani ADEL
Valentina BRACAGLIA
Umberto DELLE PIANE
Stefania RENZI

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

Operations Research
Andrea CRISTOFARI
Michela DI LULLO
Giacomo LANZA
Maryam SALAMY M. Curie Scholarship

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

Bioengineering
Alessandra ANZOLIN
Stefano CASCHERA

Operations Research
Lavinia AMOROSI
Andrea CALICIOTTI
Fabio SCIAMANNINI - Dual Degree
Stefano FOGLIETTA

XXXI course

Automatica
Daniele DE SIMONE
Marco FERRO
Federico LISI
Mattia MATTIONI - Dual Degree
Khaled AL KHUDIR

Bioengineering
Stefano BERTULETTI
Emma COLAMARINO
G. Guachi ROBINSON
Matilde BERTOLI
Marianna INGLESE

Operations Research
Anna MELCHIORRI
Ludovica MACCARONE
Marco VIOLA
Serena MANTOVANI - Dual Degree
Gianluca MORGANTI - Dual Degree

PhD theses completed in 2015

Automatica

Francesco LIBERATI
Model Predictive Control-based Demand Response in Smart Grids
Advisor: Francesco DELLI PRISCOLI

Giovanni MATTEI
Robust nonlinear control: from continuous time to sampled-data with aerospace applications
Advisor: Salvatore MONACO - Dorothee NORMAND-CYROT

Antonio PAOLILLO
Vision-based control of humanoid robots interacting with the real world
Advisor: Alessandro DE LUCA

Letterio ZUCCARO
Resource allocation algorithms in energy, IT and telecommunication networks
Advisor: Francesco DELLI PRISCOLI

Operations research

Andrea MANNO
Decomposition Algorithms for Learning Systems
Advisor: Stefano LUCIDI

Valentina MINNETTI
On the parameters of the Electre Tri method: a proposal of a new two steps procedure
Advisor: Renato DE LEONE

Alessandra REALE
Application of Combinatorial Optimization arising from large scale Census Surveys
Advisor: Renato BRUNI

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 2015.

Sebastian SARDINA, RMIT University, Melbourne, Australia, January 2015.

Yves LESPERANCE, York University, Toronto, Canada, January 2015.

Henk F. MOED, Elsevier, Amsterdam, Holland, February-June 2015.

Nick HAWES, University of Birmingham, Birmingham, United Kingdom, March-May 2015.

Subramanian RAMAMOORTHY, University of Edinburgh, Edinburgh, United Kingdom, March-May 2015.

Leopold SIMAR, Emeritus Professor, Université Catholique de Louvain, Belgium, April-June 2015.

Oguzhan ERDINC, Turkish Air Force Academy, Turkey, May 2015.

Marina ROMANENKO, North-Caucasus Federal University, Stavropol, Stavropol Krai, Russia, September 2015.

Carlos CASTILLO, Eurecat, Barcelona, Spain, Fall 2015.

Evimaria TERZI, Boston University, Boston, Massachusetts, United States, Fall 2015.

David ISRAEL, SRI International, Menlo Park, California, United States, October-December 2015.

Shunjie LI, Nanjing University of Information Science and Technology, Nanjing, China, October-December 2015.

George GIORGIOU, Towson University, Washington D.C., United States, October-December 2015.

Ming-Li CHIANG, National Taiwan University, Taipei, Taiwan, whole year 2015.

2.6 Seminars and Workshops

Many scientists are invited to deliver seminars at DIAG. Below is the list of seminars for the year 2015, in chronological order. Workshops organized at DIAG are also reported, providing the link to their description.

- February 20, Workshop Efficiency, Effectiveness and Impact of Research and Innovation, `http://www.diag.uniroma1.it/en/node/6994`

- February 25, Workshop SAPHARI @DIAG, `http://www.diag.uniroma1.it/node/6995`

- March 19, Kolmogorov meets Turing: Workshop on probabilistic methods for the analysis of stochastic processes and randomized algorithms, `http://www.diag.uniroma1.it/node/7007`

- March 25, Eugenia Ternovska (Simon Fraser University), Modular Systems: Semantics, Logic, Algorithms, Complexity

- March 25, Google Workshop su Sviluppo di Applicazioni Cloud e Web `http://www.diag.uniroma1.it/node/7014`

- March 31, Leonid Libkin (University of Edinburgh), SQL's Three-Valued Logic and Certain Answers

- April 8, Leonid Libkin (University of Edinburgh), Incomplete Data: What Went Wrong, and How to Fix It

- April 9, Tatiana Tommasi (ESAT KU-Leuven), Learning to learn: how far we are from the solution

- April 17, Andrea Saltelli (European Centre for Governance in Complexity), Evidence based policy at a crossroad

- April 21, Edwin Olson (University of Michigan), Confessions from the SLAMmer

- April 21, Subramanian Ramamoorthy (University of Edinburgh), Abstractions for Robots Interacting with Open Worlds

- May 4, Jie Huang, Choh-Ming Li, The Cooperative Output Regulation of Multi-agent Systems

- May 11, P. C. Yuen (Hong Kong Baptist University), Opportunities for studying in Hong Kong

- May 12, Constantine Raftopoulos (NTUA Athens, Greece), Global Curvature and the Noising Paradox for Vertex Localization in Unknown Shapes

- May 28, Workshop in honor of Luigia Carlucci Aiello on the occasion of her retirement: Artificial Intelligence and Robotics: The future belongs to them `http://www.diag.uniroma1.it/node/7053`

- June 3, Arun Kumar Singh, Mario Gianni, Federico Ferri, Challenges in 3D motion planning and control for articulated tracked robots in Urban Search & Rescue

- June 12, Paul W. Wilson (Clemson University, USA), Assessing Knowledge Production in US Universities - MORE@DIAG

- June 16, Kazuya Yoshida (Graduate School of Engineering, Tohoku University, Sendai, Japan), Space Robots and Micro Satellites at Tohoku University

- June 17, Maxim Sviridenko (Yahoo! Research NY), Jannik Matuschke (TU Berlin & Univ. of Tor Vergata), Bart de Keijzer (Sapienza Univ. of Rome), Tom McCormick (Univ. of Bristish Columbia) , Algorihtms Lunch Talks@DIAG

- June 18, C. Mohan (IBM Almaden Research Center), Modern Database Systems: Modernized Classic Systems, NewSQL and NoSQL

- June 22, Nicolo' Cesa-Bianchi (University of Milan La Statale), An algorithmic approach to nonparametric online learning

- June 23, Claudio Semini and Michele Focchi (Dynamic Legged Systems lab, IIT), Design and Control of High-performance Hydraulic Quadruped and Centaur Robots

- July 1, CINI - Presentation of Laboratorio Nazionale Smart Cities & Communities

- July 2, Rocco De Rosa (Universitá di Milano), Action Recognition in Streaming Videos via Incremental Active Learning

- July 3, Michael Beetz (Institute for Artificial Intelligence, University of Bremen, Germany), openEASE - A Knowledge Processing Service for Robots and Robotics Researchers

- July 13, Febo Cincotti (DIAG, Sapienza University), Real-time processing of neurophysiological signals to improve, restore and enhance human functions

- July 15, Aristidis Anagnostopoulos (DIAG, Sapienza University), Models and Algorithms for Online Crowd Systems

- July 15, Massimo Mecella (DIAG, Sapienza University), Challenges in Knowledge-intensive Processes: Mining for Semi-structured Information and Providing Runtime Automated Adaptation

- July 16, Elena Bertozzi (Quinnipiac University), Game (r)evolution

- July 20, Fabio Nonino (DIAG, Sapienza University), What drives collective innovation? The impact of motivations on the attraction of innovation roles in open innovation web-based platforms

- September 10, Anthony Cohn (University of Leeds), Learning about activities, spatial relations and spatial language from video

- October 13, Rosa Maria Dangelico (DIAG, Sapienza University), Green product innovation: where we are and where we are going

- October 16, Allan Borodin (University of Toronto), The power and limits of online and greedy-like algorithms for the unconstrained non-monotone submodular maximization problem

- October 26, Philippe Fraisse (UM-LIRMM, France), Parsimonious kinematic control for highly redundant robots

- October 29, Shoya Higa (Space Robotics Laboratory, Tohoku University), Stress distribution beneath the wheel of a lunar/planetary rover on loose soil

- October 30, Jakub Lacki (Sapienza University of Rome), Dynamic Steiner Tree

- November 6, Bart de Keijzer (Centrum Wiskunde & Informatica), Sequential Posted Price Mechanisms

- November 10, Workshop Challenges of Big Data for Economic Modeling and Management: Tools from Efficiency Analysis, Sensitivity Analysis, Sensitivity Auditing and Physics of Complex Systems, http://www.dis.uniroma1.it/node/7171

- November 13, Carlos Castillo (EURECAT), Big Crisis Data - an exciting frontier for applied computing

- November 25, Othon Michail (Computer Technology Institute & Press Diophantus): Foundations of Dynamic Networks

- November 27, Evimaria Terzi (Boston University), Entity Selection and Ranking for Data Mining applications

- December 1, OPTICAR European Users Workshop `http://www.diag.uniroma1.it/node/7167`

- December 1, Laura Astolfi (DIAG, Sapienza University), From finger tapping to the social brain: advanced methods for the estimation of brain activity and connectivity in humans

- December 2, Massimiliano de Leoni (Eindhoven University of Technology), Multi-perspective Conformance Checking

- December 4, Francesco Pasquale (University "Tor Vergata", Rome), Self-Stabilizing Dynamics for Distributed Consensus

- December 4, Giorgio Gnecco (IMT School for Advanced Studies Lucca), Machine learning models and techniques

- December 11, David Israel (Stanford Research Institute), Thoughts on Goals and Methods in Artificial Intelligence

- December 17, Tsvi Kuflik (University of Haifa) - Automatic Detection of Social Behavior of Museum Visitor Pairs

- December 18, David Israel (Stanford Research Institute), Machine Reading: Goals and Approaches

- December 18, Marcello La Rosa (Queensland University of Technology), Liquid Process Model Collections

- December 21, Fabrizio Pece (ETH Zurich), Making Everything Interacting: New ways of interaction in the Ubiquitous Computing Age

2.7 Awards and Recognitions

- Giuseppe De Giacomo: ACM Fellow, December 2015.

- Salvatore Monaco, Member of the Scientific Committee and Strategic Committee of Italian-French University UIF/UFI, from June 2015.

- Stefano Leonardi was one of the three general chairs of the 24th International World Wide Web Conference (WWW 2015), held in May 2015.

The following papers were awarded:

- Emanuele Magrini, Fabrizio Flacco, Alessandro De Luca: Control of generalized contact motion and force in physical human-robot interaction, Proc. 2015 IEEE International Conference on Robotics and Automation, ICRA 2015 Best Conference Paper Award Finalist.

- Francisco Facchinei (with Scutari G., Song P., Palomar D.P., and Pang J.-S.): Decomposition by partial linearization: Parallel optimization of multi-agent systems, published in IEEE Transactions on Signal Processing, won IEEE Signal Processing Society Young Author Best Paper Award.

- Gianni Di Pillo, Stefano Lucidi, Massimo Roma (with M. Fabiano): Optimal deployment of a cruise fleet, AIRO best application paper 2015.

- Leonardo Lanari (with Hutchinson S.): Planning desired center of mass and zero moment point trajectories for bipedal locomotion, Proc. 2015 IEEE-RAS International Conference on Humanoids, Humanoids 2015 Best Interactive Paper Award Finalist.

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 € 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 € 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 31-12-2016

- CIP € 212.200, VOICE - Virtual Open Incubation Ecosystem, M. Mecella, ending 31-08-2017

- ERC-STG € 331.151, PAAl - Practical approximation algorithms, S. Leonardi, ending 31-10-2015

- ERC-STG € 1.496.277, RoboExNovo - Robots learning about objects from externalized knowledge sources, B. Caputo, ending 31-05-2019

- H2020 € 366.750, FLOURISH - Aerial Data Collection and Analysis, and Automated Ground Intervention for Precision Farming, D. Nardi, ending 31-08-2018

- H2020 € 719.215, COMANOID - Multi-contact Collaborative Humanoids in Aircraft Manufacturing, G. Oriolo, ending 31-12-2018

- H2020 € 507.500, SYMPLEXITY - Symbiotic human-robot collaboration for safe and dynamic multimodal manufacturing systems, A. De Luca, ending 31-12-2018

- H2020 € 993.750, SECONDHANDS - SecondHands: A Robot Assistant For Industrial Maintenance Tasks, F. Pirri, ending 30-04-2020

- H2020 € 180.277, SAT-STABILIS - Nonlinear Sampled-data Attitude Stabilization of Underactuated Spacecraft, S. Monaco, ending 30-09-2017

Contracts with Italian Institutions

- MIUR - PON € 759.698, PLATINO - PLATform for INnOvative services in future internet, F. Delli Priscoli, ending 30-06-2015

- MIUR - PON € 181.512, NEPTIS - Soluzioni ICT per la fruizione e l'esplorazione"aumentata" di Beni Culturali, T. Catarci, ending 31-12-2016

- CHIST-ERA € 250.298, ALOOF - Autonomous Learning of the Meaning of Objects, B. Caputo, ending 30-09-2017

- CHIST-ERA € 240.100, COACHES - Cooperative Autonomous robots in Complex and Humans EnvironmentS , L. Iocchi, ending 30-09-2017

Contracts with Companies

- 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

- 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

- 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

- 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

- 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 Dir. Gen.per i Sistemi di Trasporto ad impianti fissi ed il TPL € 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 fiscalità dell'auto, M. Lenzerini, ending 31-03-2015

- CONSORZIO MIP - Politecnico di Milano € 15.000 Attività di consulenza relative al progetto di Action Learning"Analisi per i dirigenti-responsabili dei servizi di contabilità e bilancio delle università italiane", G. Catalano, ending 06-08-2015

- A.N.A.V. - Associazione Nazionale Autotrasporto Viaggiatori € 30000 Esecuzione di una ricerca concernente lo studio, la comparazione e le opportunità di integrazione dei servizi di TPL su ferro e su autobus, G. Catalano, ending 15-06-2015

- ANCI - Associazione Nazionale dei Comuni Iitaliani € 20000 Realizzazione Corso di Formazione "Le gare per l'affidamento dei servizi di trasporto pubblico locale" nell'ambito della Convenzione ANCI-UPI con Ministero dell'Interno del 12-12-2013 per l'avvio del progetto "Piano annuale per la formazione territoriale dei segretari comunali e provinciali, del personale degli Enti locali e degli amministratori locali", G. Catalano, ending 30-04-2015

- ANCI - Associazione Nazionale dei Comuni Iitaliani € 20000 Realizzazione Corso di Formazione " Gli enti locali e l'agenda digitale- metodologie di individuazione, progettazione e realizzazione dei servizi on-line e degli open data per le smart communities locali"" nell'ambito della Convenzione ANCI-UPI con Ministero dell'Interno del 12-12-2013 per l'avvio del progetto "Piano annuale per la formazione territoriale dei segretari comunali e provinciali, del personale degli Enti locali e degli amministratori, A. Marchetti Spaccamela, ending 30-04-2015

- AgID - Agenzia per l'Italia Digitale € 39000 Attività di studio e ricerca giuridica per il passaggio dal sistema di contabilità finanziaria a quello di contabilità economico-patrimoniale. Servizio di supporto, consulenza e formazione, G. Catalano, ending 26-04-2016

- TELECOM ITALIA S.p.A. € 70000 Sviluppo di una ontologia e mapping tra ontologia e sorgenti di dati, M. Lenzerini, ending 31-12-2015 SIAE - Società Italiana degli Autori ed Editori € 15000 Esecuzione di un programma di ricerca nell'ambito della Sezione Musica SIAE denominato "Programmi Puliti" volto a costruire un sistema di intelligence-raccolta informazioni che permetta di effettuare accertamenti mirati, L. Palagi, ending 14-11-2015

- CONFCOOPERATIVE - Confederazione Cooperative Italiane € 4820 Addendum 1 al Contratto 2014 - Esecuzione ricerca sul tema "Connessioni interoperative settoriali (Aree Metropolitane, Codice appalti, Recepimento delle Direttive europee sugli appalti, centrali pubbliche di acquisto)", G. Catalano, ending 28-08-2015

- ADF Service s.r.l. € 12000 Esecuzione di una ricerca concernente l'analisi dei costi e dei risultati economico-finanziari aggiornati almeno parzialmente al 2014, di un opportuno campione di imprese di distribuzione farmaceutica e la stima del costo unitario del servizio di distribuzione, C. Leporelli, ending 28-07-2015

- ACI Informatica S.p.A. € 120000 Ricerca sul tema "Integrazione dei dati basata su ontologie nel dominio della fiscalità dell'auto", M. Lenzerini, ending 31-12-2015

- GAUSS s.r.l. € 45000 Attività di studio, concezione, progettazione e supporto alla realizzazione prototipica di un sottosistema per il controllo di assetto a tre assi per UNISAT-7, S. Monaco, ending 15-07-2016

- AREMOL - Agenzia Regionale per la Mobilità € 20000 Elaborazione delle metodologie per l'applicazione del costo standard per la gestione delle ferrovie concesse nel territorio della Regione Lazio, A. Avenali, ending 08-05-2016

- DIIIE - Dip. Di Ingegneria Industriale dell'Informazione e di Economia dell'Università dell'Aquila. € 15000 Ottimizzazione globale multi-obiettivo di un motore Brushless a MP di tipo "spoke-type" mediante analisi agli Elementi Finiti 2D, S. Lucidi, ending 16-06-2016

- TELECOM ITALIA S.p.A. € 20000 Strumenti di visualizzazione per dati di traffico, G. Santucci, ending 31-12-2015

Research Agreements (Convenzioni)

- ADF Service srl, ending 14-10-2015

- AERO SEKUR SPA, ending 03-06-2016

- ASSOCIAZIONE NAZIONALE AUTOTRASPORTO VIAGGIATORI "ANAV", ending 10-12-2015

- ASSTRA - ASSOCIAZIONE TRASPORTI, ending 15-07-2015

- 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

- DIS Dipartimento per la Sicurezza, ending 04-10-2018

- 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

- INTERSAJ SRL, ending 17-02-2017

- 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

- STIE SPA, ending 05-04-2017

- 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 Areas

The Department scientific activities are distributed along six Research Areas that are responsible for identifying and coordinating research programs and for supporting teaching activities. Each area includes one or several research groups. Research areas are:

- **Biomedical Engineering**

- **Economics**

- **Engineering in Computer Science**

- **Management Engineering**

- **Operations Research**

- **Systems and Control Engineering**

3.1 Biomedical Engineering

3.1.1 Bioengineering and Bioinformatics

Research lines:

- Analysis and Modelling of Metabolic Systems

- Methods and Techniques for Neuroengineering

- Bioengineering for Molecular Biology and Bioinformatics

- Processing and analysis of bioelectrical signals

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

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

Post Docs: Francesca Schettini, Jlenia Toppi.

The research activity in this area deals with the applications of the general methodologies of modelling, estimation, signal processing, machine learning and statistics to the study of physiological and biological systems. Researches on biomedical applications have been performed since the early 70's with regard to biomechanics, prostheses and modelling of cellular growth. At present, the group is 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.

Research goals include: the study of the mechanisms on the basis of insulin secretion and on the insulin resistance; the potential application of the Brain Computer Interface (BCI) techniques in the rehabilitation of stroke patients; 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.

Among other international recognitions, in 2015 Laura Astolfi has been elected Chair of the Technical Committee di IEEE EMBS in Biomedical Signal Processing.

Several national and international cooperations are actually active, among which: Dip. di Fisiologia Umana e Farmacologia, Sapienza Università di Roma; Dip. di Biotecnologie Cellulari ed Ematologia, Sapienza Università Roma; IRCCS Fondazione Santa Lucia (Roma); Istituto di Medicina Interna Università Cattolica - Policlinico A. Gemelli (Roma); Laboratorio di Oncogenesi Molecolare, Istituto Nazionale Tumori Regina Elena (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; 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; Institute of Medical Statistics, Computer Sciences and Documentation, Friedrich Schiller University, Jena, Germany; Functional Brain Mapping Laboratory, University of Geneva, Switzerland; Perceptual Networks Group, University of Fribourg,Switzerland; Computational Cognitive Neuroscience Lab, Indiana University, Bloomington, USA; Dpt. of Biomedical and Electrical Engineering - University of South California (USA); ECE Kansas State University (USA); New Zealand Brain Research Institute, Christchurch, New Zealand.

Projects:

- *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 2013 (Responsabile L. Astolfi).

- *Definition and validation of brain connectivity indices for the evaluation of cortical plasticity induced by neurorehabilitation.* Progetto di Ateneo 2014 (Responsabile L. Astolfi).

- *Toward an EEG-based model of working memory deficits after stroke: diagnosis and rehabilitation.* Progetto di Ateneo - Avvio alla ricerca 2015 (Responsabile J. Toppi).

- *APOSTROPHES - Assisting Post Stroke Rehabilitation through real time Physiological Signal analisys.* Progetto di Ateneo 2015 (Responsabile F. Cincotti).

- *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 (Responsabile L. Astolfi).

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

- *Convenzione stipulata tra il Dipartimento e l'IRCCS Fondazione Santa Lucia per il cofinanziamento (66%) di una borsa triennale per il Corso di Dottorato di Automatica, Bioingegneria e Ricerca Operativa, XXX ciclo.*

Journals

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doi: 10.1016/j.neurobiolaging.2014.09.011

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[3] Colombo T., Farina L., Macino G., Paci P., PVT1: A rising star among oncogenic long noncoding RNAs, *BioMed Research International*, article ID 304208 (10 pages), 2015.
doi: 10.1155/2015/304208

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3.2 Economics

3.2.1 Innovation, Internationalization and the Environment

Research lines:

- R&D and Innovation

- Internationalization and the Environment

- Mergers and Alliances in Oligopolistic Markets

- The Governance of Nonprofit Organizations

- Migration and Inovation

Members: Marco Antonio Marini, Francesca Sanna-Randaccio (leader), Roberta Sestini.

Post Docs: 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 the 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.

Innovation and Diffusion of Clean Technologies   This stream of empirical research question is motivated by increased concern that the fragmentation of EU renewable energy research and innovation systems may hamper the ability to address climate challenges at socially acceptable costs. We build a knowledge diffusion econometric model to investigate whether demand-pull environmental measures, introduced with the 1997 Commission White Paper and following Directives, had an impact on the fragmentation of EU research and innovation effort in the strategic field of renewable energy. By focusing on knowledge spillovers, we study the pattern and evolution of knowledge flows within the EU and between the EU and two frontier innovators: the United States and Japan.

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.

Endogenous Alliance and Merger Formation in Vertically Differentiated Markets   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.

Vertical Differentiation and Collusion: Cannibalization vs. Proliferation   We consider the dilemma of pruning versus proliferation in a vertically differentiated oligopoly under the assumption that some firms collude and control both the range of variants for sale and their corresponding prices, likewise a multiproduct firm. We analyse whether pruning emerges and, if so, a fighting brand is marketed. We find that it is always more

profitable for colluding firms to adopt a pricing strategy such that some variants are withdrawn from the market. Under pruning, these firms commercialize a fighting brand only when facing competitors in a low-end market. The same findings do not hold when firms are horizontally differentiated along a circle.

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 Migration and 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] Marini M. A., Polidori P., Teobaldelli D., Zevi A., Welfare Enhancing Coordination in Consumer Cooperatives under Mixed Oligopoly, *Annals of Public and Cooperative Economics* 86(3), 505-527, 2015.

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[4] Conti C., Mancusi M.L., Sanna-Randaccio F., Sestini F., Verdolini E., Intra-EU Knowledge Flows in the Renewable Energy Sector: a Patent Citations Analysis, *Proceedings IFKAD 2015 (International Forum on Knowledge Asset Dynamics)*.

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3.3 Engineering in Computer Science

3.3.1 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, Emilio Coppa.

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

- Principles of Design and Analysis of Algorithms: re-optimization techniques for combinatorial problems, models of computation for very large data sets;

- Experimental Algorithmics: implementation and engineering of advanced algorithms and data structures for graph problems;

- Performance Engineering: design and implementation of methodologies and tools for analing 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

Journals

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[12] Anagnostopoulos A., Sorella M., Learning a macroscopic model of cultural dynamics, In Charu Aggarwal, Zhi-Hua Zhou, Alexander Tuzhilin, Hui Xiong, and Xindong Wu, editors, *Proceedings of the 2015 IEEE International Conference on Data Mining, ICDM 2015*, 685–690, 2015.

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3.3.2 Artificial Intelligence and Knowledge Representation

Research lines:

- Description Logics

- Logics for AI

- Semantic Technologies

- Reasoning about Actions & Planning

- AI for Games

- Human-Robot Interaction

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

PhD Students: Davide Aversa, Cristina Civili, Marco Console, Lorenzo Lepore, Valerio Santarelli.

Post Docs: José Mora, Marco Ruzzi.

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

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

The Semantic Technologies aim at intelligent information processing by creating and connecting machine-understandable information, sometimes called the Semantic Web. Our research in this area mainly focuses on representation languages, in particular for ontologies. 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.

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 or automated process synthesis 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.

Another research direction investigates a variety of challenges that relate to applying academic AI in the practical domain of video games, in particular in two main directions, one that focuses on the behavior of characters in games and one that focuses on the underlying storyline of a video game. In the first direction we extend pathfinding to take into account the beliefs and capabilities of the character, e.g., answering questions of the form: "What is the most promising way for a character to go from A to B taking into account their recent observations?", and "what is the fastest way for a character to go from A to B when they can also pick up items that open blocked pathways?", essentially identifying restricted planning problems. In the second direction we look into tools and methodologies for allowing game designers and story authors to offer interactive narratives that are verified to be free of deadlocks, which following an MVC-like approach can also act as a well-structured Model (game logic) according to which different Views (game environments such as 2D or 3D or text-based) can be attached via appropriate Controllers (AI-structured game engines) to procedurally generate variants of games.

One specific application where knowledge representation has been applied is the interpretation of spoken commands in the context of human robot interaction. The knowledge about the environment and the robot capabilities is used by the system in order to build the language that specifies robot commands. By suitably restricting the language, the performance of grammar based speech understanding engine can be substantially improved.

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

- Editorial activities

  - Giuseppe De Giacomo, Review Editor of Artificial Intelligence, Elsevier.
  - Giuseppe De Giacomo, Steering Committee Member of the International Conference on Principles of Knowledge Representation and Reasoning (KR).
  - Giuseppe De Giacomo, Area chair of 25th International Joint Conference on Artificial Intelligence (IJCAI 2016).

- Giuseppe De Giacomo, Fellow Committee Member of the European Coordinating Committee for Artificial Intelligence, 2015.
- Giuseppe De Giacomo, Reviewer for the European Research Council (ERC) Consolidator grants, 2015.
- Maurizio Lenzerini, Editorial Board member of Intelligenza Artificiale, The International Journal of the AI*IA.
- Maurizio Lenzerini, Area Editor of Journal of Applied Logic for the area of Logic for Knowledge Representation and the Semantic Web.
- 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, Area Editor of Logic Journal of the IGPL (Oxford Journal of the Interest Group in Pure and Applied Logic), for the area of Logic for Knowledge Representation and the Semantic Web.
- Maurizio Lenzerini, Member of the ACM SIGMOD Awards Committee, since 2013.
- Maurizio Lenzerini, Member of the evaluation committee of INRIA (the French National Institute for computer science and applied mathematics), 2015.
- Riccardo Rosati, Member of the Editorial Board of Artificial Intelligence, Elsevier.
- Riccardo Rosati, Steering Committee Member of the International Workshop on Nonmonotonic Reasoning (NMR), since 2012.
- Riccardo Rosati, Steering Committee Member of the International Conference on Web Reasoning and Rule Systems (RR), since 2012.

- Invited Talks:

  - Giuseppe De Giacomo, "On Bounded Situation Calculus", invited talk at HYBRIS Workshop, Potsdam, Germany June 2015.
  - Giuseppe De Giacomo, "Synthesis in Linear-time Dynamic Logic on Finite Traces", keynote at Highlights of Logic, Games and Automata 2015 (Highlights 2015), Prague, Czech Republic, September 2015.
  - Giuseppe De Giacomo, "Temporal Reasoning in Bounded Situation Calculus", keynote at 22nd International Symposium on Temporal Representation and Reasoning (TIME), Kassel, Germany, September 2015.
  - Maurizio Lenzerini, "Giochi di logica: dai paradossi a Godel", invited lectures at the "Mathesis, la ricerca in matematica" conference, Roma, 26 febbraio 2015.

Projects:

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

- *ICE : Immersive Cognitive Environments*, Award Sapienza research project:, December 2015 - December 2018. Giuseppe De Giacomo.

- *SPIRITLETS: SPIRITLET-based Smart spaces*, Award Sapienza research project. November 2013 - April 2015. Giuseppe De Giacomo.

- *Speaky Acutattile*, Ministero dello Sviluppo Economico (Industria 2015). June 2011 - April 2015. Luigia Carlucci Aiello and Daniele Nardi.

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[2] De Giacomo G., Lespérance Y., Patrizi F., and Vassos S., Progression and Verification of Situation Calculus Agents with Bounded Beliefs. In *Studia Logica Journal*, 1–35, 2015.

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[15] De Giacomo G., Ntouskos V., Patrizi F., Vassos S., and Aversa D., Service Composition with PDDL Representations and Visualization over Videogame Engines (Short Paper), *Proc. of the 8th IEEE International Conference on Service-Oriented Computingv-vand Applications (SOCA 2015)*, 101–107, 2015.

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Submitted papers, technical reports and others

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[24] De Giacomo G., Lespérance Y., and Patrizi F., Bounded Situation Calculus Action Theories, CoRR, abs/1509.02012, 2015.

3.3.3   Artificial Intelligence and Robotics

Research lines:

- Robot World Modeling

- Information Fusion

- Social Robotics and Human-Robot Interaction

- Robot Learning

- Multi-Agent and Multi Robot Systems

- Robotic Competitions and Benchmarking

Members: Domenico Daniele Bloisi, Giorgio Grisetti, Luca Iocchi, Daniele Nardi (leader), Alberto Pretto.

PhD Students: Guglielmo Gemignani, Fabio Previtali, Taigo Maria Bonanni, Roberto Capobianco, Maurilio Di Cicco, Jacopo Serafin, Francesco Riccio, Marco Imperoli, Ciro Potena, Andrea Vanzo, Ali Youssef.

Post Docs: María Teresa Lázaro, Andrea Pennisi.

The research in this area is at the intersection between Artificial Intelligence and Robotics, and has its roots in the early AI research that targeted robots as embodiments of the intelligent agent.

The key scientific challenge, which has received a significant push by the recent developments in sensor technology and robotics, is the ability to deal with manifold representations of knowledge that enables robots to perform complex tasks in a dynamic, unknown environment populated by other (robotic and human) agents. One section of the work aims at analizing perceptual data to create a rich world model, through the interpretation of sensor data and/or data coming from other information sources, including spoken language understanding. Another section of the research aims at developing various types of inference to support the actions of the robot in the environment, in particular within social contexts and in the interaction with the user. Both perception and action are often addressed in scenarios where multiple agents cooperate both in distributed perception and in task execution.

The research group builds on the experience acquired through robotic competitions in the context of RoboCup, started back in 1998, not only in robot soccer, but also in Rescue, @Home and @Work competitions. Hence, one characterizing aspect of the research approach is a strong emphasis on the experimental validation of the proposed technical solutions through the implementation of system prototypes and their evaluation through suitable benchmarking methodologies.

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, agriculture and service robots. Specifically, the problem of sensor fusion and situation awareness has been targeted in the framework of maritime surveillance.

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, soccer robot vision applications (GNAO), IMBS, PHIS, PTracking, NICP, IMU-TK, D2CO, EasyDepthCalibration, and the data sets data sets for maritime surveillance (MarDT), and data set for spoken command understanding (Huric).

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, 2015.

- Daniele Nardi has been Past President of the RoboCup Federation, 2015.

- The SPQR team of humanoid soccer players participated in RoboCup 2015 Hefei, China, and the SPQR@Work team participated in the RoCKIn competition in Lisbon.

- Daniele Nardi and Giorgio Grisetti have been Local Organizers of the Conference *Robotics Systems and Science*, Rome, July 11-15 2015.

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.

- *Flourish* (EU Horizon2020). March 2015 - September 2018. Alberto Pretto, Giorgio Grisetti, and Daniele Nardi.

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3.3.4   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, Ioannis Chatzigiannakis, Alberto Marchetti Spaccamela (leader), Leonardo Querzoni, Andrea Vitaletti.

PhD Students: Fabio Angeletti, Francesco Ficarola, Mario Paoli

Post Docs: 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 Sapienza 2014

- *ArcheoBOT – Towards a Scientific Approach in Archaeological Excavations* - Progetto Interdisciplinare Sapienza 2015

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3.3.5 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: Fiora Pirri (leader), Barbara Caputo, Marco Schaerf, Mario Gianni, Luca Iocchi, Luigi Freda.

PhD Students: Angela Di Iorio, Federico Ferri, Valentina Franzoni, Manuel Alejandro Ruiz Garcia, Valsamis Ntouskos, Marta Sanzari, Fabrizio Natola, Fabio Maria Carlucci.

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 adap-

tation 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:

- *RoboExNovo - Robots learning about objects from externalized knowledge sources* - 2015, 2020 - ERC-2014-STG

- *SecondHands - A Robot Assistant for Industrial Maintenance Tasks* - 2015, 2020 - H2020 ICT-2014-1

- *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

- Innovation: Problem or challenge? Istituto Superiore Antincendi (ISA, Vigili del Fuoco), 2015, Rome.

- TRADR Project Exhibition, IROS 2015, Hamburg.

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3.3.6 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, Antonella Poggi, Riccardo Rosati, Silvio Salza, Domenico Fabio Savo, Stavros Vassos.

PhD Students: Cristina Civili, Marco Console, Lorenzo Lepore, Valerio Santarelli.

Post Docs: Javier Fernandez, Francesco Leotta, 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 enterprize 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 2015, members of the research group have been invited to organize various events, and to deliver keynote speeches at various conferences and workshops. The following is a list of such activities:

- Giuseppe De Giacomo, Editorial Board Member of Acta Informatica, Springer.

- Domenico Lembo, Program co-Chair of the 23rd Italian Symposium on Advanced Database Systems (SEBD 2015).

- Maurizio Lenzerini, Area Editor of Information Systems - An International Journal for the area of Data Modeling and Knowledge Representation and Reasoning Techniques.

- Maurizio Lenzerini, Associate Editor of ACM Journal of Data and Information Quality (JDIQ).

- Maurizio Lenzerini, Editorial Board member of Big Data Research, Elsevier.

- Maurizio Lenzerini, Steering Committee member of the Sistemi Evoluti di Basi di Dati (SEBD) conference.

- Maurizio Lenzerini, Keynote talk at the 8th IEEE International Conference on Service Oriented Computing & Applications (SOCA 2015).

- Maurizio Lenzerini, Member of the Executive Committe of the ACM Principles of Database Systems (PODS), since 2006.

- Maurizio Lenzerini, Member of the Scientific Advisory Board of BiCi - Bertinoro international Center for informatics.

- Maurizio Lenzerini, Member of the Advisory Board of the European Research Institute in Service Science (ERISS).

- Antonella Poggi, Invited Speaker at the 23rd Italian Symposium on Advanced Database Systems, (SEBD 2015).

- Riccardo Rosati, Keynote talk at the 9th International Conference on Web Reasoning and Rule Systems (RR 2015).

- Riccardo Rosati, Keynote talk at The 12th International Conference on Mobile Web and Intelligent Information Systems (MobiWis 2015).

Projects:

- Research project funded by Sapienza: "MODEUS - Making Open Data Effectively USable, November 2014 - October 2015.

- UK Engineering and Physical Sciences Research Council (EPSRC) Project EP/I00520X/1 *Trusted Autonomous Systems*, joint with Alessio Lomuscio, Imperial College London, 2010-2015.

- GenData2020 - Data-driven Genomic Computing, MIUR PRIN 2010, February 2013 - January 2016.

- 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).

- SIR research project funded by MIUR, grant n. RBSI14TQHQ: MODEUS - Making Open Data Effectively USable, September 2015 - September 2018.

- Research project funded by Regione Lazio: MAGISTER - Multidimensional Archivial Geographical Intelligent System for Territorial Enhancement and Representation, November 2015 - October 2017.

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3.3.7 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, Romaric Ludinard, 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 mission-critical systems, early warning systems and smart environments.

Projects:

- *SUNFISH* - January 2015, December 2017 - EU H2020.

- *PANOPTESEC* - November 2013, October 2016 - EU IP FP7.

- *EURASIA* - October 2016, October 2018 - Progetto accordo Italia-Israele.

- *ROMA - Resilience Enhancement of Metropolitan Areas* - November 2013, November 2016 - MIUR Smart Cities.

- *XASMOS* - January 2014, December 2015 - Industrial project with Finmeccanica.

- *CIS-SOGEI Collaboration* - June 2015, May 2016 - Industrial project.

- *T-NOVA - Network Functions as-a-Service over Virtualised Infrastructures* - January 2014, December 2016 - EU Strep FP7.

- *TENACE, Protecting National Critical Infrastructures from Cyber Threats* - February 2013, January 2016 - PRIN MIUR.

- *DMI - Digital Market Intelligence* - October 2013, April 2015 - Regional project.

- *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.

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[3] Anceaume E., Busnel Y., and Rivetti N., Estimating the Frequency of Data Items in Massive Distributed Streams, *Proceedings of the IEEE Fourth Symposium on Network Cloud Computing and Applications (NCCA)*, 2015.

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3.3.8 High Performance and Dependable Computing Systems

Research lines:

- Parallel and Distributed Computing Platforms

- Operating Systems

- High Performance Computing

- Multicore Programming

- Multi-tier Architectures

- Transactional Systems

- Virtualization and Cloud Computing

- Non-blocking/Wait-Free Algorithms

- Software Instrumentation and Compiling Techniques

- Performability Models

- Heterogeneous Computing

Members: Bruno Ciciani (leader), Francesco Quaglia.

PhD Students: Davide Cingolani, Simone Economo, Mauro Ianni.

Post Docs: Pierangelo Di Sanzo, Alessandro Pellegrini.

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 design and development of innovative operating system services oriented to support high performance computing applications and data intensive ones;

- binary instrumentation to transparently inject non-functional, rather performance/reliability-oriented capabilities, within general applications;

- the design of techniques for improving energy-efficiency of applications deployed on massively-parallel machines

- the design and/or exploitation of transactional memory paradigms, either software- or hardware-based;

- 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. Some of the publicly-released packages have been already adopted by other (foreign) research centers/industrial parties.

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 sequential/concurrent programming based (a) on transparent and automatic techniques supporting reverse computing schemes as a mean for maintaining causal consistency as well as guaranteeing fault tolerance and security, and to enable reversible/post-mortem debugging (b) transparent injection via instrumentation of non-functional logic within generic applications so as to guarantee the possibility to drive the execution of these applications while optimizing resource/energy usage as well as performance.

Projects:

- *SIGMA: Sistema Integrato di sensori in ambiente Cloud per la Gestione Multirischio Avanzata - 2013–2015*

- *SATURN: Spatio-Temporal Cloud Store for Big-Data Applications - 2015–*

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[23] Pellegrini A., Quaglia F., A Time-Sharing Time Warp System, ACM Transactions on Modeling and Computer Simulation, submitted.

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[25] Pellegrini A., Peluso S., Quaglia F., Vitali R., Transparent Speculative Parallelization of Discrete Event Simulation Applications Using Global Variables, International Journal of Parallel Programming, pending revision.

[26] Pellegrini A., Peluso S., Quaglia F., Vitali R., Analysis, Classification and Comparison of Scheduling Techniques for Software Transactional Memories, IEEE Transactions on Parallel and Distributed Systems, submitted.

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3.3.9 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: Annalisa Terracina, Marco Angelini

Post Docs: Andrea Marrella, Francesco Leotta

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:

- *NEPTIS* - January 2015 – December 2016 - Italian PON (PON03PE_00214)

Journals

[1] Limongelli C., Sciarrone F., Temperini M., A social network-based teacher model to support course construction, *Computers in Human Behavior* 51, 1077–1085, 2015, Elsevier.

[2] Terracina A., Mecella M. Game School: Teaching STEM through Mobile Apps and Role-based Games, *IEEE Technical Committee on Learning Technology Bullettin* 17(3), 2015.

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[3] Bottoni P., Catarci T., De Marsico M., and Fogli D., *Proc. of the 11th Biannual Conference on Italian SIGCHI Chapter, CHItaly 2015*.

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[6] Angelini M., Prigent N., Santucci G., PERCIVAL: proactive and reactive attack and response assessment for cyber incidents using visual analytics, *Proc. 2015 IEEE Symposium on Visualization for Cyber Security (VizSec 2015)*, Chicago, IL, USA, October 25, 2015.

[7] Angelini M., Santucci G., Visual Cyber Situational Awareness for Critical Infrastructures, *Proc. 8th International Symposium on Visual Information Communication and Interaction (VINCI 2015)*, Tokyo, Japan, August 24-26, 2015, 83-92.

[8] Cucari G., Leotta F., Mecella M., and Vassos S., Collecting Human Habit Datasets for Smart Spaces through Gamification and Crowdsourcing, *Proc. of Games and Learning Alliance conference*, 2015.

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[12] Humayoun S.R., Sharf M., AlTarawneh R., Ebert A., and Catarci T., ViZCom: Viewing, Zooming and Commenting through Mobile Devices. *Proc. of the 2015 International Conference on Interactive Tabletops & Surfaces, ITS 2015*, 15–18, 2015.

[13] Renzi M., Vassos S., Catarci T., and Kimani S., Touching Notes: A Gesture-Based Game for Teaching Music to Children. In *Proc. of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction, TEI 2015*, 603–606, 2015.

[14] Terracina A., Mecella M., Building an emotional IPA through empirical design with high-school students, *Proc. 9th European Conference on Games Based Learning (ECGBL 2015)*, 2015.

3.3.10   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 (graduated in 2/2016), Noor Aldeen Alawad, Reem Atassi, Riccardo Colini Baldeschi (graduated in 2/2016), Adriano Fazzone, Mara Sorella.

Post Docs: Diodato Ferraioli, Bart de Keijzer, Jakub Łącki, Francesco Pasquale, Qiang Zhang

We can group our activities in four main areas: (1) analysis of dynamic processes, (2) social-network analysis, (3) auctions and game theory, and (4) algorithms for mining.

The analysis of dynamic processes allows to understand better the evolution of various phenomena that occur in computation. A simple process that we studied is a balls-into-bins process, in which load is moved according to some random process. This setting can model load transfer between machines. We study its self-stabilization properties with respect to the maximum (bin) load and some related performance measures. We also study the all-logit dynamics, which model the interactions between players in a network. We also investigated convergence and incentive compatibility conditions of almost best-response mechanisms, where players are not guaranteed to always best respond but they rather play an imperfect best-response strategy. Such mechanisms are being used to study distributed protocols. Finally, we studied the plurality consensus in the gossip model, which models opinion formation in networks.

A part of our group's effort has been dedicated to analyze processes in social networks. We studied the notorious problem of influence maximization, under the presence of competitors. We also looked at the effect of the presence of altruism and spite when users play a game against each other. We stidied the evolution of socio-cultural systems, and, in particular, the effect of inluence and selection, by observing real data. Finally, we measured the effect of polarization and of homophily in the spreading of misinformation.

This year we continued our work on auctions and on mechanism design. We studied multiple keyword sponsored search auctions with budgets. We gave the first mechanism for multiple keywords, where click-through rates differ among slots. Our mechanism is incentive compatible in expectation, individually rational in expectation, and Pareto optimal. We also considered the problem of designing efficient mechanisms to share the

cost of providing some service to a set of self-interested customers. Such settings arise naturally whenever customers can be served in two different ways: either by being part of a common service solution or by being served individually All our mechanisms are essentially best possible with respect to budget balance and social cost approximation guarantees. We also studied the inefficiency of equilibrium outcomes in Bottleneck Congestion games, which are games that model situations in which strategic players compete for a limited number of facilities. Moreover, we studied the revenue performance of sequential posted price mechanisms and some natural extensions, for a general setting where the valuations of the buyers are drawn from a correlated distribution. Finally, we looked at the sequential price of anarchy a concept that compares sequential with contemporaneous decisions.

To conclude the description of our activities, we designed algorithms for mining in diverse settings. In the crowdsourcing setting, we compared the use of expert and naïve workers, and we designed effective algorithms for ranking that make careful use of the available resources. We designed algorithms that, given a collection of documents and a distribution over user queries, return a small subset of the document collection in such a way that we can efficiently provide high quality answers to user queries using only the selected subset. This approach has applications when space is a constraint or when the query-processing time increases significantly with the size of the collection. Finally, we studied the limits of robust hierarchical k-center clustering by introducing the concept of universal hierarchical clustering and provide (almost) tight lower and upper bounds for the robust hierarchical k-center clustering problem with outliers and variants of the stochastic clustering problem.

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.

Journals

[1] Anagnostopoulos A., Becchetti L., Bordino I., Leonardi S., Mele I., Sankowski P., Stochastic query covering for fast approximate document retrieval, *ACM Transactions on Intelligent Systems* 33(3), 1–35, 2015.

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[3] Auletta V., Ferraioli D., Pasquale F., Penna P., Persiano G., Logit dynamics with concurrent updates for local interaction potential games, *Algorithmica* 73(3), 511–546, 2015.

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[7] Gupta A., Könemann J.,Leonardi S., Ravi R., Schäfer G., Efficient cost-sharing mechanisms for prize-collecting problems, *Mathematical Programming* 152(1), 147–188, 2015.

Conference proceedings

[8] Adamczyk M., Borodin A., Ferraioli D., de Keijzer B., Leonardi S., Sequential posted price mechanisms with correlated valuations, *Proc. 11th Conference on Web and Internet Economics (WINE 2015)*, 1–15. Springer, 2015.

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[11] Anagnostopoulos A. Sorella M., Learning a macroscopic model of cultural dynamics, In *Proc. of the 15th International Conference on Data Mining (ICDM 2015)*, 685–690. IEEE Computer Society, 2015. (short paper).

[12] Becchetti L., Clementi A., Natale E., Pasquale F., and Posta M., Self-stabilizing repeated balls-into-bins, *Proc. 27th ACM Symposium on Parallelism in Algorithms and Architectures (SPAA 2015)*, 332–339. ACM, 2015.

[13] Becchetti L., Clementi A., Natale E., Pasquale F., and Silvestri R., Plurality consensus in the gossip model, *Proc. 26th Annual ACM-SIAM Symposium on Discrete Algorithms (SODA 2015)*, 371–390. SIAM, 2015.

[14] Bessi A., Petroni F., Vicario M. D., Zollo F., Anagnostopoulos A., Scala A., Caldarelli G., QuattrociocchiW., Viral misinformation: The role of homophily and polarization, *Proc. of the 24th International World Wide Web Conference, Companion Volume (WWW 2015, Web Science Track)*, 355–356, 2015.

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[16] Lattanzi S., Leonardi S., Mirrokni V., Razenshteyn I., Robust hierarchical k-center clustering, *Proc. 6th ACM International Conference on Innovations on Theoretical Computer Science (ITCS 2015)*, ITCS '15, 211–218, New York, NY, USA, 2015. ACM.

3.4 Management Engineering

3.4.1 Industrial Organization and Management

Research lines:

- Competition, Regulation and Industrial Policy

- Mechanism Design and Auctions

- Economics and Management of Education and Research

- Efficiency and Productivity Analysis

- Management Control Systems

- Operations Management

- Industry Studies: Media, Telecommunications, Transportation, Utilities, and Services

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

PhD Students: Valentina Bracaglia, Milad Dehghani, Federica Di Camillo, Cosimo Dolente, Mojtaba Khorram Niaki, Giulia Palombi, Luigi Scuncio.

Post Docs: Tiziana D'Alfonso, Flavia Di Costa.

The research activity of the group, 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 students, 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) and of the observatory on Local Public Transport of the Ministry of Infrastructures and Transport (MIT), 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 Ministry of infrastructures and Transport and the European Commission on the themes of the evaluation of the impact of public policies for higher education and scientific research and on the themes of the standard cost of local public transport.

Projects:

- 2012-2017: Elsevier Bibliometric Research 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;

- 2013-2015: Sapienza Research Project no. C26A13ZXRY, Efficiency, Effectiveness and Impact of Universities and Schools;

- 2013-2015: European Tertiary Education Register (ETER), European Commission, Contract No. EAC-2013-038;

- 2014-2016: Sapienza Research Awards no. (C26A14YJL5) An incentive pricing mechanism for efficient airport slot allocation;

- 2015-2018: H2020: BONVOYAGE - Intermodal mobility solutions, interfaces and applications for people and goods, supported by an innovative communication network;

- 2013-2015: Sapienza Research Awards no. C26N1339HR, Airlines-High Speed Rail cooperation and competition;

- 2013-2015: Sapienza Research Awards no. C26N1483ET Intermodality between air transport and high speed rail: social welfare, environmental externalities and regulation;

- 2013-2015: Sapienza Research Project no. C26N15NAZK, Multiproduct transport facilities: pricing and regulation;

- 2015-2017: Implement and Disseminate the European Tertiary Education Register (ETER 2015-2017), European Commission, Contract No. EAC-2015-0280;

- 2015-2017: Sapienza Research Awards no. (C26H15XNFS) Establishing a Knowledge Infrastructure for the Development of Methodologies for the Assessment of Research and its Impacts;

- 2015-2017: Sapienza Research Awards no. (C26N15TJLN) Methods and procedures for the determination of standard costs in the local public bus transport sector;

- 2015-2017: Sapienza Research Awards no. (C26A15ZBPM) Co-investment in ultrafast broadband access networks: is there a role for content providers?.

Journals

[1] Agasisti T., Arena M., Catalano G., Erbacci A., Defining spending reviews: a proposal for a taxonomy, with applications to Italy and UK, *Public Money and Management* 35(6), 2015.

[2] Agasisti T., Catalano G., Di Carlo F., Erbacci A., Accrual accounting in Italian universities:a technical perspective, *International Journal of Public Sector Management* 28(6), 494-508, 2015.

[3] Albino V., Berardi U., Dangelico R.M., Smart cities: definitions, dimensions, performance, and initiatives, *Journal of Urban Technology* 22(1), 3-21, 2015.

[4] Avenali A., Boitani A., Catalano G., D'Alfonso T., Matteucci G., Costi standard per finaziare il TPL: E' ora?, *Trasporti pubblici*, XXXI(7-8), 42-48, 2015.

[5] Avenali A., D'Alfonso T., Leporelli C., Matteucci G., Nastasi A., Reverberi P., An Incentive Pricing Mechanism for Efficient Airport Slot Allocation in Europe, *Journal of Air Transport Management* 42, 27-36, 2015.

[6] Avenali A., Leporelli C., Matteucci G., Reverberi P., Vertical Control and Parallel Trade Under Asymmetric Information, *International Journal of Engineering Business Management* 7(1), 1-11, 2015.

[7] Avenali A., Matteucci G., Reverberi P., Can Access Regulation Promote Broadband Investment and Consumer Welfare?, *International Journal of Technology, Policy and Management* 15(4), 357-377, 2015.

[8] Costantino F., Di Gravio G. and Nonino F., Insights from action research: implementing an innovative lean procurement framework for global sourcing, *International Business Management* 47, 28, 3008-3019, 2015.

[9] Costantino F., Di Gravio G. and Nonino F., Project Selection in Project Portfolio Management: an Artificial Neural Network Model based on Critical Success Factors, *International Journal of Project Management* 33(8), 1744-1754, 2015.

[10] Curi C., Daraio C., Llerena P., The productivity of French Technology Transfer Office after government reform, *Applied Economics* 9(4), 416-424, 2015.

[11] De Toni A.F., Fornasier A. and Nonino F., The Impact of Implementation Process on the Perception of Enterprise Resource Planning Success, *Business Process Management Journal* 21(2), 332-352, 2015.

[12] Dehghani M., Tumer M., A research on effectiveness of Facebook advertising on enhancing purchase intention of consumers, *Computers in Human Behavior* 49, 597-600, 2015.

[13] D'Alfonso T., Daraio C., Nastasi A. Competition and Efficiency in the Italian airport system: new insights from a conditional nonparametric frontier analysis, *Transportation Research Part E: Logistics and Transportation Review* 80, 20-38, 2015.

[14] Dangelico R.M., Pontrandolfo P., Being "green and competitive": the impact of environmental actions and collaborations on firm performance. *Business Strategy and the Environment* 24(6), 413-430, 2015.

[15] D'Alfonso T., Jiang C., Bracaglia V., Would competition between air transport and high speed rail benefit environment and social welfare?, *Transportation Research Part B: Methodological* 74, 118-137, 2015.

[16] Dangelico R.M., Improving Firm Environmental Performance and Reputation: The Role of Employee Green Teams, *Business Strategy and the Environment* 24(6), 413-430, 2015.

[17] Daraio C., Bonaccorsi A., Simar L., Efficiency and economies of scale and specialization in European universities. A directional distance approach, *Journal of Informetrics* 9, 430-448, 2015.

[18] Daraio C., Bonaccorsi A., Simar L., Rankings and University Performance: a Conditional Multidimensional Approach, *European Journal of Operational Research* 244, 918-930, 2015.

[19] Jiang C., Wan Y., D'Alfonso T., Strategic choice of alliance membership under local competition and global networks, *Journal of Transport Economics and Policy* 49, 316-337, 2015.

[20] Laise D., Marraro L., Iazzolino G., Metachoice for Benchmarking: a case study, *Benchmarking: an international journal* 22(3), 338-353, 2015.

Articles in books

[21] Agasisti T., Catalano G., Autonomia efficienza ed equità nel sistema universitario. Storia, effetti e prospettive, in *Ambrosanio, F., Bordignon, M., Galmarini, U., Rizzo L., Finanza pubblica, decentramento e riforme costituzionali. Scritti in onore di Piero Giarda, Vita e Pensiero Editrice*, Milano, 157-194.

[22] Barbieri G., Catalano G., D'Alfonso T., Petretto A., Un modello per la distribuzione del personale docente delle scuole tra le regioni, in *Ambrosanio, F., Bordignon, M., Galmarini, U., Rizzo L., Finanza pubblica, decentramento e riforme costituzionali. Scritti in onore di Piero Giarda, Vita e Pensiero Editrice*, Milano, 131-156, 2015.

[23] Catalano G., Agasisti T., Erbacci A., Definizione di una tassonomia della spending review, in *AAVV, Ingegneria e Management. Scritti in onore di Umberto Bertelè, Francesco Brioschi Editore*, Milano, 29-52, 2015.

Books

[24] Daraio C.(Eds), Efficiency, Effectiveness and Impact of Research and Innovation, Proceedings of the Workshop Efficiency, Effectiveness and Impact of Research and Innovation, Sapienza University of Rome, ISBN 9788899104306, Efesto Edizioni, Roma, May 2015.

[25] Laise D., La natura dell'impresa capitalistica, ISBN 8875341362, EGEA, Milano, 2015.

Conference proceedings

[26] Annarelli A., Battistella C., Nonino F., Operations Management for Sustainable Competitiveness, *Proceedings of the 22nd European Operations Management Association (EurOMA) Conference, paper MAS-01*, 1-33, Tallin, Estonia, Neuchatel, Switzerland,26 June - 1 July, 2015.

[27] Avenali A., Boitani A., Catalano G., D'Alfonso T., Matteucci G., Assessing standard costs in local public transport: evidence from Italy, *Proceedings of the the Kuhmo NEC-TAR conference on Transportation Economics ITEA*, Oslo, Norway, 17-19 June, 2015.

[28] Avenali A., Boitani A., Catalano G., Matteucci G., Un modello per la determinazione del costo standard nei servizi di trasporto pubblico ferroviario regionale, *Proceedings of the XXVI Riunione Scientifica AiIG*, Vicenza (Italia), 15-16 October, 2015.

[29] Battistella C., Annarelli A., Nonino F., Exploring the Impact of Organizational and Working Models, Incentives and Collaboration Strategies on Innovation Development in Online Communities of Practices, *Proceedings of the 16th European Conference on Knowledge Management (ECKM)*, Reading, UK: Academic Conferences and Publishing International Limited, Udine, Italy, 3-4 September, 2015.

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3.5 Operations Research

3.5.1 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 Bioinformatics

- Satisfiability in Propositional Logic

- Information Reconstruction

- Robust Optimization

Members: Renato Bruni, 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.

- Tecniche di Data Mining efficienti, robuste e basate sull'ottimizzazione per la risoluzione di problemi di Classificazione e Selezione di Investimenti, progetto di ricerca Sapienza, Dec. 2014 - May 2016.

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[2] R. Bruni, G. Bianchi, Effective Classification using Binarization and Statistical Analysis. *IEEE Transactions on Knowledge and Data Engineering* 27(9), 2349-2361, 2015.

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3.5.2   Continuous Optimization

Research lines:

- Nonlinear Optimization

- Derivative Free Methods

- Global Optimization

- Semidefinite Programming

- Variational Inequalities

- Bilevel Optimization

- Mixed Integer Nonlinear Programming

- Big Data Optimization

- Simulation–based optimization

- Parallel and distributed optimization methods

- Game Engineering

- Neural Networks and Support Vector Machines

- Engineering Design Optimization

- Resource allocation in communication networks

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

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

Post Docs: 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 and Nonlinear Conjugate Gradient 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.

- Optimization of ship itineraries for a cruise fleet.

- 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.

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[3]   Cardellini V., De Nitto Personé V., Di Valerio V., Facchinei F., Grassi V., Lo Presti F., and Piccialli V. A game-theoretic approach to computation offloading in mobile cloud computing, *Mathematical Programming*. Published online: April 9, 2015. DOI: 10.1007/s10107-015-0881-6.

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[6]   Daneshmand A., Facchinei F., Kungurtsev V., and Scutari G.,   Hybrid random/deterministic parallel algorithms for convex and nonconvex big data optimization, *IEEE Transaction on Signal Processing* 63, 3914–3929, 2015.

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3.6 Systems and Control Engineering

3.6.1 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 (emeritus), Antonio Pietrabissa.

PhD Students: Federico Cimorelli, Andrea Lanna, Lorenzo Ricciardi Celsi, Letterio Zuccaro.

Post Docs: Silvia Canale, Andrea Fiaschetti, Francesco Liberati, Guido Oddi, Martina Panfili, Vincenzo Suraci.

The networked systems area has developed, in the last 13 years, thanks to the successful participation in 36 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, intermodal mobility solutions for people and goods, space assets for demining assistance, wireless cognitive sensor networks.

Projects:

- *Bonvoyage, From Bilbao to Oslo, intermodal mobility solutions and interfaces for people and goods, supported by an innovative communication network* (managed by CRAT) - May 2015, April 2018 - EU MG H2020 Project.

- *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-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

- *PLATINO* - July 2012, June 2015 - Progetto MIUR PON.

- *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.

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[27] Zuccaro L., Resource Allocation Algorithms in Energy, IT and Telecommunication Networks. Tesi di dottorato in Ingegneria dei Sistemi, XXVII ciclo, Marzo 2015.

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[28] Delli Priscoli F., Di Giorgio A., Facchinei F., Liberati F., Gambuti R., Palagi P., Pietrabissa A., Suraci V., Profiled Quality of Experience Control, submitted to *IEEE Transactions on Automation Science and Engineering*, June 2015.

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[33] Ricciardi Celsi L., Lisi F., Pietrabissa A., Suraci V., Monaco S., Delli Priscoli F., Multi-Agent Quality of Experience Control, submitted to *International Journal of Control, Automation and Systems*, December 2015.

Patents

[34] Canale S., Delli Priscoli F., Mignanti S., Sassano S., Suraci V., Metodo per la fruizione personalizzata di trasmissioni digitali, e relativo sistema, brevettato dall'Università di Roma "La Sapienza", rilasciato nel 2015, Brevetto RM2012A000283.

3.6.2 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, Paolo Di Giamberardino, Daniela Iacoviello, Alberto Isidori (leader ad honorem, emeritus), Salvatore Monaco (leader).

PhD Students: Raffaello Bonghi, Lorenzo Ricciardi Celsi, Mattia Mattioni.

Post Docs: 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. Possible improvements in optimal control problems by means of piecewise continuous cost functions are also under investigation as a new research line in the framework of nonlinear switching control methods. This kind of approach brings to significant improvements when dealing with limited resources or under a high level decision process on the cost of the action or on the priority of the intervention. 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:

- *SARFIRE* February 2010 - February 2012 - ASI,

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

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[12] Battilotti S., Delli Priscoli, F., Gori Giorgi, C., Pietrabissa, A., Suraci, V., Zuccaro, L., A Future Internet interface to control programmable networks, In *23rd Mediterranean Conference on Control and Automation*, 2015.

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[17] A. Kaldmäe, C.H. Moog, C. Califano, Towards integrability for nonlinear time-delay systems, In *MICNON* , IFAC-PapersOnLine 48 (11), 900–905 , Saint Petersburg, Russia , 2015.

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[29] Liberati F., *Model Predictive Control-based Demand Response in Smart Grids*, Dottorato in Ingegneria dei Sistemi XXVII Ciclo.

[30] Mattei G., *Robust nonlinear control: from continuous time to sampled-data with aerospace applications*, Dottorato in Ingegneria dei Sistemi XXVII Ciclo - Doppio Titolo.

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[32] Andreaus U., Baragatti P., Casini P., Iacoviello D., Experimental damage evaluation of open and fatigue cracks of multi-cracked beams by using wavelet transform of static response via image analysis, submitted to *Structural Control and Health Monitoring*, 2015

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3.6.3 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), Leonardo Lanari, Giuseppe Oriolo, Marilena Vendittelli.

PhD Students: Khaled Al Khudir, Gabriele Buondonno, Marco Cognetti, Daniele De Simone, Marco Ferro, Claudio Gaz, Emanuele Magrini, Valerio Modugno, Federico Patota.

Post Docs: Massimo Cefalo, Fabrizio Flacco, Antonio Paolillo, 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.

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 Khepera III by K-Team), legged (a NAO humanoid robot by Alde-baran, 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. The latest addition is an haptic interface with 3D force feed-back (Geomatic Touch). 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 (IP FP7 ICT-287513) [coordinator].

- *COMANOID, Multi-Contact Collaborative Humanoids in Aircraft Manufacturing* - January 2015–December 2018 (RIA H2020-ICT-2014-1, 645097).

- *SYMPLEXITY, Symbiotic Human-Robot Solutions for Complex Surface Finishing Operations* - January 2015–December 2018 (IA H2020-FoF-2014, 637080).

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Articles in books

[5] De Luca A., Robotica. In *Enciclopedia italiana di scienze, lettere ed arti, Appendice IX* 2, 444–446, Istituto della Enciclopedia Italiana, Roma, 2015.

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