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

Research Report 2018
## Contents

1 Introduction 1

2 General Information 2
   2.1 Location 2
   2.2 Facilities 2
   2.3 People 6
   2.4 Doctoral Programs 8
   2.5 Visiting Scientists and Scholars 13
   2.6 Seminars and Workshops 13
   2.7 Honours and Awards 16
   2.8 Contracts 17

3 Research Areas 20
   3.1 Biomedical Engineering 21
      3.1.1 Bioengineering and Bioinformatics 21
   3.2 Economics 24
      3.2.1 Innovation, Internationalization and the Environment 24
   3.3 Engineering in Computer Science 26
      3.3.1 Algorithm Design and Engineering 26
      3.3.2 Algorithms and Data Science 29
      3.3.3 Artificial Intelligence and Knowledge Representation 30
      3.3.4 Artificial Intelligence and Robotics 34
      3.3.5 Computer Networks and Pervasive Systems 37
      3.3.6 Cybersecurity 39
      3.3.7 Data Management and Service-Oriented Computing 43
      3.3.8 Distributed Systems 47
      3.3.9 High Performance and Dependable Computing Systems 49
      3.3.10 Human-Computer Interaction 51
   3.4 Management Engineering 54
      3.4.1 Industrial Organization and Management 54
   3.5 Operations Research 57
      3.5.1 Combinatorial Optimization 57
      3.5.2 Continuous Optimization 59
   3.6 Systems and Control Engineering 62
      3.6.1 Networked Systems 62
      3.6.2 Nonlinear Systems and Control 64
      3.6.3 Robotics 67

4 Publications 69
1 Introduction

The present document is a report about the research activity carried out in 2018 at the Department of Computer, Control, and Management Engineering “Antonio Ruberti” (DIAG) of the Sapienza University of Rome.

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 2018 consists of 23 full professors, 26 associate professors, and 20 assistant professors (ricercatori). They offer educational services at undergraduate and graduate level 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), and at graduate level to the Master in Product Design, of the school of Architecture (Facoltà di Architettura), with main responsibility in the curricula in informatics, systems and control, and engineering management. Details about teaching activities are not reported in this document; a description may be found at [http://www.diag.uniroma1.it](http://www.diag.uniroma1.it) under section “Teaching”. DIAG offers also two PhD programs, and cooperates with a PhD program offered by another department. They are briefly described in Section 2.4 of this report.

DIAG’s research activity is organized in 6 research areas, each composed of one or more research groups. An overview of the groups is reported in Section 3, together with the list of people involved, in 2018. A collection of the Department’s publications for 2018 is reported in Section 4.
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

Founded in 1969, the Library of the Department collects books and periodicals related to computer science, control theory, robotics and management engineering. It owns over 12,000 volumes and 450 periodicals. The Library complements its collection with user access to all the key online resources, bibliographic databases, eBooks (accessible both on the library website and in the central online catalog), and scientific content discovery services. In particular, the Library provides access to the main databases in IT and management, i.e. IEEE Library, ACM Library and Derwent Innovation. The Library is open from 8.30 to 19.30, Saturday from 9 to 13. There are two reading rooms available for students, for a total of 87 places. The Library facilities are also available to students and faculty of other departments and universities. In addition to the normal librarian activity, the Library organized presentations of the department’s degree courses (OpenDIAG), conferences on specific topics, and book presentations. The Library has also organized a project for the Alternanza Scuola Lavoro for 20 secondary school students. Finally, the Library staff helps professors to insert the research products in the IRIS database.

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
2.2 Facilities

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 B213, 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 A215, 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 DUELLI PRISCOLI

DIAG Robotics Lab
Via Ariosto 25 - basement
The laboratory focuses on the development of advanced planning and control techniques for both industrial and service robots. Experimental validation takes place on fixed-base manipulators, mobile robots, humanoids and flying robots.
Web: [http://www.diag.uniroma1.it/~labrob](http://www.diag.uniroma1.it/~labrob)
Head: Giuseppe ORIOLO

**ROCCO - COgnitive COoperating RObots Laboratory**
Via Ariosto 25 - basement
The laboratory deals with the experimental activities aiming at the implementation of intelligent robots, in several application domains, including agricultural robotics, robots for cultural heritage and service robots. The laboratory is responsible of the SPQR team, which participates in several international robotics competitions. Web: [http://www.diag.uniroma1.it/~labrococo/](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/](http://www.diag.uniroma1.it/~syscon/)
Head: Paolo DI GIAMBERARDINO

**Web Algorithmics and Data Mining Laboratory (WADAM)**
Via Ariosto 25 - room A220, wing A2
The laboratory is devoted to the design of algorithms for web and data-mining related problems.
Web: [http://wadam.diag.uniroma.it](http://wadam.diag.uniroma.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/wns-group/](http://www.diag.uniroma1.it/~ficarola/wns-group/)
Head: Andrea VITALETTI

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

**Educational Laboratories**

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

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 (up to October 2018)
Tiziana CATARCI (since November 2018)

Administration Head  Venerino FILOSA

Professors
Giorgio AUSIELLO (emeritus)
Roberto BALDONI
Stefano BATTILOTTI
Luigia CARLUCCI AIELLO (emeritus)
Giuseppe CATALANO
Tiziana CATARCI
Bruno CICIANI
Giuseppe DE GIACOMO
Alessandro DE LUCA
Francesco DELLI PRISCOI
Gianni DI PILO (emeritus)
Camil DEMETRESCU
Francisco FACCHINEI
Alberto ISIDORI (emeritus)
Maurizio LENZERINI
Stefano LEONARDI
Claudio LEPORELLI
Stefano LUCIDI
Alberto MARCHETTI SPACCAMELA
Salvatore MONACO
Umberto NANNI
Daniele NARDI
Alberto NASTASI
Giuseppe ORIOLO
Fiora PIRRI
Riccardo ROSATI
Francesca SANNA RANDACCIO (up to January 2018)
Antonio SASSANO
Marco SCHAEF

Assistant professors (ricercatori)
Laura ASTOLFI
Roberto BERALDI
Silvia BONOMI
Renato BRUNI
Claudia CALIFANO
Tiziana D’ALFONSO
Marianna DE SANTIS
Paolo DI GIAMBERARDINO
Alessandro DI GIORGIO
Giorgio GRISETTI
Daniela IACOVIELLO
Riccardo LAZZERETTI
Riccardo MARZANO (since March 2018)
Valsamis NTOUSKOS
Fabio PATRIZI
Antonio PIETRABISSA
Alberto PRETTO
Leonardo QUERZONI
Simone SAGRATELLA
Chris SCHWIEGELSHOHN (since October 2018)
Andrea VITALETTI

Associate professors
Aris ANAGNOSTOPOULOS
Alessandro AVENALI
Luca BECCHETTI
Luca BENVENUTI
Barbara CAPUTO
Ioannis CHATZIGIANNAKIS
Febo CINCOTTI
Fabrizio D’AMORE
Rosa Maria DANGELICO
Cinzia DARAIO
Alberto DE SANTIS
Lorenzo FARINA
Luca IOCCCHI
Domenico LAISE (up to October 2018)
Leonardo LANARI
Domenico LEMBO
Paolo LIBERATORE
Massimo MECELLA
Fabio NONINO
Laura PALAGI
Pierfrancesco REVERBERI
Massimo ROMA
Silvio SALZA (up to October 2018)
Giuseppe SANTUCCI
Roberta SESTINI
Marco TEMPERINI
2.3 People

Post Doc (research associates) and research assistants

Alessandro ANNARELLI
Andrea CALCIOTTI
Massimo CEFALO
Claudio CICCOTELLI
Marco COGNETTI
Emilio COPPA
Daniele Cono D’ELIA
Donato DELL’ATTI
Pierangelo DI SANZO
Simone ECONOMO
Adriano FAZZONE
Luigi FREDI
Claudio GAZ
Francesco LEOTTA
Emanuele MAGNINI
Andrea MARRELLA
Mattia MATTIONI
Lorenzo MAURO
Marca MELONE
Valerio MODUGNO
Giulia PALOMBI
Martina PANFILI
Alessandro PELLEGRINI
Manuela PETTI
Lorenzo RICCIARDI CELSI (up to April 2018)
Francesco RICCI
Valerio SANTARELLI
Marta SANZARI
Domenico Fabio SAVO

Chris SCHWIEGELSHOHN (up to September 2018)
Mara SORELLA
Piero TOMA
Jlenia TOPPI
Daniele UCCI

Administration staff

Flavia CAGNIZI
Antonella CANCELLIERI
Antonietta CANGELLI
Federica CANNELLI
Ugo CINELLI
Sara CIOTTI
Sabrina GIAMPAOLETTI
Domenico MACARI
Giuseppina MELITA
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 *Automatica, Bioengineering and Operations Research*, in *Data Science* and in *Engineering in Computer Science*.

**Automatic Control, Bioengineering and Operations Research**

The Academic Board of the PhD program in Automatic Control, Bioengineering and Operations Research is coordinated by Giuseppe ORIOLO.

This PhD program is the result of merging the two former PhD programs in Systems Engineering and in Operations Research, and has now three curricula, i.e., Automatic Control, Bioengineering, and Operations Research. The research topics are: systems theory, nonlinear and optimal control, control applications, robotics, networked systems, metabolic systems, neuroengineering, bioinformatics, bioelectrical signal processing, combinatorial optimization, nonlinear programming, network design, neural networks, logistics.

**PhD Students**

**XXXI course**
- Khaled AL KHUDIR
- Matilde BERTOLI
- Stefano BERTULETTI
- Emma COLAMARINO
- Daniele DE SIMONE
- Marco FERRO
- Robinson GUACHI
- Marianna INGLESE
- Federico LISI
- Ludovica MACCARRONE
- Serena MANTOVANI
- Mattia MATTIONI
- Anna MELCHIORI
- Gianluca MORGANTI
- Marco VIOLA

**XXXII course**
- Maria Laura ACETO
- Tommaso COLOMBO
- Massimiliano D’ANGELO
- Eduardo FERREIRA FRANCO
- Alessandro GIUSEPPI
- Giorgio GRANI
- Mohammed HAYMAN SALIH
- Maram KHATIB
- Maria Grazia PUXEDDU
- Nicola SCIANCA

**XXXIII course**
- Yuri ANTONACCI
- Barbara BARROS CARLOS
- Francesco CURIA
- Danny D’AGOSTINO
- Paolo FERRARI
- Tommaso GIOVANNELLI
- Alessio MORESCHINI
- Antonio ORNATELLI
- Francesco ROMITO
- Mirko ROSSI
- Ruggiero SECCIA
- Andrea TORTORELLI

**XXXIV course**
- Marco BORESTA
- Ilaria COCCHI
- Anna Livia CROELLA
- Mohamed ELOBAID
- Roberto GERMANÀ
- Andrea ILGRANDE
- Alessandro INGROSSO
- Esteban SALGADO
- Spyridon TARANTOS
- Edoardo Maria TRONCI
- Giulio TURRISI
2.4 Doctoral Programs

PhD theses completed in 2018

Lavinia AMOROSI
*Bi-criteria Network Optimization: Problems and Algorithms*
Advisor: Paolo DELL’OMO

Alessandra ANZOLIN
*Statistical Causality in the EEG for the Study of Cognitive Functions in Healthy and Pathological Brains*
Advisor: Laura ASTOLFI

Gabriele BUONDONNO
*Numerical Solutions for Design and Dynamic Control of Compliant Robots*
Advisor: Alessandro DE LUCA

Andrea CALICIOTTI
*Advances in Large Scale Unconstrained Optimization: Novel Preconditioning Strategies for Nonlinear Conjugate Gradient Methods and New Developments in Newton-Krylov Methods*
Advisor: Massimo ROMA

Stefano CASCHERA
*Analysis and Modeling of the EEG Activity and Connectivity in Post-Stroke Conditions*
Advisor: Laura ASTOLFI

Federico CIMORELLI
*SDN Workload Balancing and QoE Control in Next Generation Network Infrastructures*
Advisor: Francesco DELL’ELLI PRISCOLI

Nicolò GIONFRÀ
*Stratégies de Commande Distribuée pour l’Optimisation de la Production des Fermes éoliennes*
Advisor: Salvatore MONACO

Marwa HASSAN
*Nonlinear and Sampled Data Control with Application to Power Systems*
Advisor: Salvatore MONACO

Lorenzo RICCIARDI CELSI
*Nonlinear Multi-Agent Control with Application to Networked Systems*
Advisor: Salvatore MONACO

Maryam SALAMI
*Two Essays in Computational Optimization: Computing the Clar Number in Fullerene Graphs and Distributing the Errors in Iterative Interior Point Methods*
Advisor: Giovanni RINALDI

Data Science

The Academic Board of the PhD program in Data Science is coordinated by Stefano LEONARDI. Data Science is an interdisciplinary field of study that has established itself in recent years in order to offer the methodological tools and technologies necessary for the management and analysis of big data and their valorisation in industry, services, and search. The phenomenon of big data has revolutionized countless sectors of economic-social activity. The phenomenon of big data has also profoundly modified the research methodologies and the development of technological innovation in numerous disciplines and applications. The main objective of this PhD is the realization of interdisciplinary research projects of Data Science that lead to the development of innovative methodologies and technologies based on the use of big data in the following fields of application: i) Advanced digital platforms, ii) Management of urban spaces and environmental resources iii) Medicine and health iv) Economic and Social Analysis.

XXXIV course
Giorgio BARNABÒ
Federico FUSCO

Engineering in Computer Science

The Academic Board of the PhD program in Engineering in Computer Science is coordinated by Camil DEMETRESCU. The research topics include: 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, human-computer interaction, computer networks and security.

PhD Students

XXXI course
Simone ECONOMO
Marco IMPEROLI
Ciro POTENA
Marta SANZARI
Ali YOUSSEF

XXXII course
Dario ALBANI

Gianluca CIMA
Bartolomeo DELLA CORTE
Paola FERRARELLI
Valentina GREGORI
Giuseppe LAURENZA
Massimiliano MANCINI
Marotta ROMOLO
Nizar MASSOUH
Francesco PUJA
Paolo RUSSO
2.4 Doctoral Programs

Filipp SAMOILOV
Dominik SCHLEGEL
Mahmoud SHARF
Lun WANG

XXXIII course
Irvin ALOISE
Mirco COLOSI
Stefano CONOCI
Federico CROCE
Antonio D’INNOCENTE
Giovanni FARINA
Michele GENTILI
Simone LENTI
Luca MASSARELLI
Cristina MENCHINI
Stefano PIERSANTI
Francesco SAPIO
Federico Maria SCAFAGLIERI
Emiliano SILVESTRI

XXXIV course
Marco BORESTA
Simone AGOSTINELLI
Edoardo ALATI
Graziano BLASILLI
Luca BORZACCHIELLO
Lorenzo BRIGATO
Carlos CARBONE
Stefano CARNÀ
Jim Martin CATACORA OCANA
Jesus Fernando CEVALLOS MORENO
Paolo FANTOZZI
Marco FAVORITO
Mulham FAWAKHERJI
Lauren Stacey FERRO
Daniele FILOSCIA
Manuel NAMICI
Simone NICCHI

PhD theses completed in 2018

Mara SORELLA
BMining Dynamics of User Preferences in Complex Networks
Advisor: Aristidis ANAGNOSTOPOULOS

Valentina FRANZONI
A Unified Approach to Semantic and Topological Similarity in Information Networks
Advisor: Marco SCHAERF

Federico LOMBARDI
Autoscaling Techniques and Blockchain-based Architectures for Performant and Dependable Complex Distributed Systems
Advisor: Silvia BONOMI

Daniele UCCI
Privacy-Preserving Data Sharing into Collaborative Environments
Advisor: Roberto BALDONI

Federico FERRI
Computing Fast Search Heuristics for Physics-based Mobile Robot Motion Planning
Advisor: Fiora PIRRI

Francesco RICCIO
Spatial Representation for Planning and Executing Robot Behaviors in Complex Environments
Advisor: Daniele NARDI

Manuel Alejandro RUIZ GARCIA
Contact Aware Robust Semi-Autonomous Teleoperation of Mobile Manipulators
Advisor: Fiora PIRRI

Andrea VANZO
Supporting Situated Spoken Human-Robot Interaction through Perceivable Context
Advisor: Daniele NARDI
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 2018.

- Henk F. **Moed**, visiting professor within the PRIN 2015 Project DIAG, September-December 2018.
- Claude **Moog**, Directeur de Recherche Cnrs, Laboratoire des Sciences du Numérique de Nantes, France.
- Léopold **Simar**, Université Catholique de Louvain, Louvain la Neuve, Belgium, March - April 2018.

2.6 Seminars and Workshops

Many scientists are invited to deliver seminars at DIAG. Below we report the list of seminars for the year 2018, in chronological order. We also report the workshops and special scientific events organized at DIAG.

- January 10, 2018, Viviana Betti, Santa Lucia: *Resting state networks as spatio-temporal priors for natural vision.*
- January 11, 2018, Cinzia Daraio, MORE@DIAG Seminars: *The Problem of Democratization of Evaluation and Altmetrics.*
- February 2, 2018, AISM@DIAG: *Affrontare la complessità della sclerosi multipla: dalla medicina al data analytics.*
- February 21, 2018: *Automazione: La figura professionale dell’Ingegnere - Incontro tra aziende e studenti.*
- March 8, 2018, Henk Moed, MORE@DIAG Seminars: *New developments in Applied Evaluative Informetrics.*
- March 15, 2018, Mario Morroni, University of Pisa, MORE@DIAG Seminars: *Georgescu-Roegen’s flow-fund model, uncertainty, innovation and the theory of the firm.*
• March 19, 2018, Minoru Asada: Cognitive Developmental Robotics: yesterday, today, and tomorrow.


• March 22, 2018, Omer Gold, Tel-Aviv University: Tight Space Lower Bounds for Fault-Tolerant Approximate Diameter and Radius.

• March 26, 2018, Massimiliano Carloni: Clarivate Analytics, A brief introduction to Web of Science and InCites basics - InCites Laboratory.

• April 4, 2018, Leonid Libkin: Can We Trust SQL as a Data Analytics Tool?

• April 4, 2018, Oliver Stein and Christoph Neumann, MORE@DIAG Seminars: A feasible rounding approach for mixed-integer optimization problems.

• April 4, 2018, Oliver Stein and Christoph Neumann, MORE@DIAG Seminars: The Cone Condition and Nonsmoothness in Linear Generalized Nash Games.

• April 10, 2018, Steve Tumson, Tumson Consulting (Technology, Management, Education): Regulating Robotics.

• April 12, 2018, Divesh Srivastava: The confounding problem of private data release.

• April 12, 2018, CERIMONIA INAUGURALE MASTER di II livello in Ingegneria Gestione per le Aziende Sanitarie (IGAS).

• April 18, 2018, Rolf Krause, MORE@DIAG Seminars: Modeling, Simulation, and Uncertainty Quantification in Biomechanics.

• April 19, 2018, Joe Halpern, Cornell University: Actual Causality: A Survey.

• April 26, 2018, Roman Games 2: an informal one-day workshop on multiagent optimization.

• May 14, 2018, Giancarlo Bigi, PhD course: Algorithms for nonsmooth optimization.


• May 24, 2018, Michela Taufer: Modeling the Next-Generation High Performance Scheduler.

• May 25, 2018, Mateo Valero, University of Catalonia (UPC): Runtime Aware Architectures.

2.6 Seminars and Workshops

- June 20, 2018, Amos Uderzo, Università di Milano-Bicocca, Ph.D. course: Metric regularity of set-valued mappings with application to optimization.
- June 20, 2018, Markos Papageorgiou, School of Production Engineering and Management, Technical University of Crete: Freeway traffic control.
- June 26, 2018, Laura Astolfi: Connectivity analysis based on EEG recordings: from motor tasks to the human social brain.
- June 26, 2018, Endre Boros, Rutgers University: Justifiable and ethical learning - a mathematical view.
- July 2, 2018, Fangzhen Lin, Hong Kong University of Science and Technology: Program Verification in First-Order Logic.
- July 9, 2018, Anton Shiriaev, Norwegian University of Science and Technology: Trajectory planning for mechanical systems with two and more passive degrees of freedom.
- July 19, 2018, Juan Cortés: Sampling-based algorithms for path-finding in continuous cost-spaces: applications to robotics and structural biology.
- September 12, 2018, Luca Benvenuti, Enrico Tronci, Federico Mari (Sapienza), Leonardo Mangeruca (United Technologies Research Center), Tiziano Villa (University of Verona), Davide Bresolin (University of Padova), ABRO Ph.D. course: Hybrid systems, Computation and Control.
- September 13, 2018, Michael Lindenbaum, Technion: 3DmFV: 3D Point Cloud Classification in Real-Time using Convolutional Neural Network.
- September 19, 2018 Identificazione e Controllo Ottimo, Bioingegneria, Gestione del Traffico su Reti al DIAG, ieri, oggi e domani - A workshop in memory of Prof. Carlo Bruni.
- September 21, 2018, Giuseppe Persiano, Università di Salerno: Symmetric Searchable Encryption with Sharing and Unsharing.
- October 12 Rebecca Reiffenhauser, RWTH Aachen: An Optimal Truthful Mechanism for the Online Weighted Bipartite Matching Problem.
- October 16, 2018, Yiannis Giannakopoulos: Optimality, Approximation and Robustness in Auctions.


October 24, 2018, Jan Baumbach: *Computational Systems Medicine - What I learned about Arnold Schwarzenegger while studying breast cancer survival.*

November 8, 2018, Jonathan Fürst: *IoT Edge Computing at NEC Labs.*

November 15, 2018, Chris Nash, University of Leeds, Workshop: *Procurement design of local public transport services.*

November 27 2018, Mathias Staudigl, Maastricht University: *Hessian barrier algorithms for linearly constrained optimization problems.*

November 29, 2018, Piotr Krysta, University of Liverpool: *Equal-Cost Mechanism Design with Monitoring.*

### 2.7 Honours and Awards


- L. Iocchi, Canada-Italy Innovation Award 2018.

- S. Leonardi: *ERC Advanced Grant 2018 - 2023.*


- M. Angelini et al., Best Paper Award at VizSec2018 *ROPMate: Visually Assisting the Creation of ROP-based Exploits* 2018, IEEE Symposium on Visualization for Cyber Security (VizSec’18).

2.8 Contracts

Researches carried on at DIAG are funded by public agencies and/or companies. Some of them span over many years. For each contract, we list below contractor, funding (in Euro), title, project leader, and duration. Titles of contracts funded by Italian entities are reported in Italian.

Contracts with the European Union (EU)

- ERC AMDROMA - Algorithmic and Mechanism Design Research in Online Markets, S. Leonardi, €1.780.150, ending 30-06-2023.
- H2020 MSCA DOCMA - Disorders of Consciousness (DoC): Enhancing the Transfer of Knowledge and Professional Skills on Evidence-based Interventions and Validated Technology for a Better Management of Patients, F. Cincotti, €126.000, ending 31-12-2021.
- H2020 MSCA FIRST - virtual Factories: Interoperation suppor Ting buSiness inno vation, M. Mecella, €207.000, ending 31-12-2020.
- ERC-STG RoboExNovo - Robots learning about objects from externalized knowledge sources, B. Caputo, €1.496.277, ending 31-05-2019.

Contracts with non-EU Institutions

Contracts with Italian Institutions


- Regione Lazio ARCA - Academic Research Creativity Archives, M. Mecella, € 82,720, ending 07-02-2020.

- Regione Lazio DTC - Distretto Tecnologico per le nuove tecnologie applicate ai beni culturali, M. Mecella and M. Schaerf, € 62,224, ending 20-07-2020.

- Regione Lazio IncontraRicerca: un portale per favorire l’incontro tra la ricerca e le applicazioni, A. Marchetti Spaccamela, € 193,718, ending 7-8-2018.


Contracts with Companies


- AREMOL- REGIONE LAZIO- Agenzia regionale per la mobilità Studio a supporto dei competenti uffici regionali per analisi sui servizi minimi del trasporto pubblico locale della Regione Lazio, G. Catalano, A. Avenali, G. Matteucci, € 35,000, ending 31-12-2019.


- PRISMA SRL - Supporto per lo sviluppo del sistema CRUMBS e CRUMBS GDPR, da integrare all’interno della piattaforma Dominio di proprietà della parte Committente, G. Santucci, € 60,000, ending 26-08-2019.

- ROTA LASER - Esecuzione di una ricerca per lo studio delle tecnologie esistenti e l’analisi delle possibili soluzioni tecniche ,la definizione dei blocchi funzionali, dell’architettura tecnica della Fustella 4.0, M. Massimo, € 144,580, ending 30-07-2019.
2.8 Contracts


Research Agreements (Convenzioni)

- Azienda Ospedaliera - Complesso Ospedaliero S.Giovanni Addolorata, ending 24-3-2018.


- CESVITER - Centro Internazionale di Studi per l’Innovazione e lo Sviluppo Territoriale, ending 2-2-2019.


- CRAT Consorzio per la Ricerca nell’Automatica e nella Telecomunicazioni (funding of 2 Post-Doc positions), ending 12-12-2018.


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

- ENAC (funding of 1 Post-Doc position), ending 27-11-2019.

- Fondazione S.Lucia, ending 13-10-2019.


- INEMA S.r.l., ending 23-3-2018.

- Ministero delle Infrastrutture e dei Trasporti, ending 26-07-2019.

- NCFU (economic support for Ph.D. students), ending 31-10-2019.

- Project Management Institute - PMI, Rome Italy Chapter, ending 22-6-2018.

- Universidade do Porto, ending 23-1-2021.
3 Research Areas

The scientific activities of the Department cover six Research Areas, 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).

Post Docs: Angela Ciaramidaro, Manuela Petti, Jlenia Toppi.

PhD Students: Yuri Antonacci, Emma Colamarino, Marianna Inglese, Maria Grazia Puxeddu, Mirko Rossi.

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.

Laura Astolfi received prestigious honors (Chair of the Technical Committee di IEEE EMBS in Biomedical Signal Processing since 2015, Fellow of the European Alliance for Medical and Biological Engineering Sciences (EAMBES), Member of the 2017-19 Administrative Committee of the IEEE Society of Engineering in Medicine and Biology, EMBS), and editorial activity (Member of the Scientific Board of the International Society for Brain Electromagenetic Topography – ISBET, Theme Chair for the Annual International Conference IEEE EMBC’18, Member of the Scientific Board of the IV IEEE Middle East Conference on Biomedical Engineering – MECBME2018, Member of the Scientific Board of the VI Congresso del Gruppo Nazionale di Bioingegneria – GNB2018).

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 Sante et de la Recherche Medicales-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, L. Astolfi.
- MoRe-Net - MOtor REcovery supported by hybrid Brain-Computer Interface and complex NETwork theory Progetti di ricerca congiunti per la mobilità di studenti di dottorato di ricerca, E. Colamarino, M. G. Puxeddu.

• *Network medicine based machine learning and graph theory algorithms for precision oncology.* Progetto di Ateneo 2018, L. Farina

• *Synergies-based real-time monitoring to improve post-stroke rehabilitation.* Progetto di Ateneo - Avvio alla ricerca 2018, E. Colamarino.
3.2 Economics

3.2.1 Innovation, Internationalization and the Environment

Research lines:

- R&D and Innovation
- Migration and Innovation
- Renewable Energy Sources and Environmental Policies

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

Post Docs: Chiara Conti.

This group has investigated the theoretical explanations and empirical implications of some interrelated phenomena, namely, technological innovation - with a particular emphasis on R&D agreements - , location decision by firms in international oligopolies, environmental policies and their role in spurring innovation, and coalition formation in oligopolies. 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.

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

**Endogenous R&D Agreements over Time** We introduced 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 was to bridge two usually separate streams of literature, the noncooperative formation of alliances (R&D agreements, mergers etc.) and the endogenous timing literature. This allowed to consider the formation of firms’ agreements over time. The models are currently also employed to study the endogenous formation of environmental agreements among different countries.

**Innovation and Diffusion of Clean Technologies** This stream of empirical research is motivated by the 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 the intensity and direction of knowledge spillovers in the strategic field of renewable energy technologies. In particular we examine the pattern and evolution of knowledge flows within the EU and between the EU and two frontier innovators: the US and Japan. We assess whether demand-pull environmental measures (starting from the 1997 Commission White Paper and following Directives) had an impact on the fragmentation of EU research and innovation space. Our results provide suggestive, but convincing evidence
that the reduction in fragmentation emerged as a result of the EU support for renewable energy technologies.

**Strategic formation of R&D agreements in presence of spillovers and informational asymmetries**  This research line aims to analyze firms’ incentives to invest in R&D under uncertainty and imperfect appropriability of the results of the research process. In particular, we investigate the extent to which firms’ R&D productivity and R&D spillovers affect the decision to sign agreements aimed to cooperation in R&D activities. For this purpose, we use a game-theoretical oligopoly model to identify the mechanisms underlying firms’ strategic decisions. The results obtained from the theoretical model contribute to explain some puzzling empirical evidence regarding the formation and the features of R&D cooperation agreements (such as RJVs). Moreover, we find a signaling role of cooperation agreements, able to foster efficient outcomes and welfare improvement. This confirms the importance of policies encouraging R&D collaboration among firms.

**Migration, externalities and innovation**  This strand of research is motivated by the importance to analyze the effects and the implications of migration on firms’ innovative performance and strategic competitiveness, with a focus on Italian sub-regions. This research, although focused on a single country, can be informative also for other countries with a similar economic structure, which are likely to be affected by large immigration in the near future. The study is conducted using advanced econometric models supported by patent data and firms’ self-reported innovation measures (CIS data), and focuses on the role of substitution or complementarity between natives’ and migrants’ skill structure. A particular attention is devoted to the possible consequences of the inflow of cheap labor force in a country specialized in traditional, low value-added production. The estimation results do not show any significant negative effect on innovation, thus suggesting that low-skilled immigration does not represent a real shock in labor supply.
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.

Post Docs: Andrea Ribichini, Emilio Coppa, Daniele Cono D’Elia.

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

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

- Principles of Design and Analysis of Algorithms: re-optimization techniques for combinatorial problems, models of computation for very large data sets;
- Experimental Algorithmics: implementation and engineering of advanced algorithms and data structures for graph problems;
- Performance Engineering: design and implementation of methodologies and tools for analyzing and optimizing software systems;
3.3 Engineering in Computer Science

- 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.
Giorgio Ausiello is editor of the following journals:

- Theoretical Computer Science - Series A.
- Computer Science Review.
- SN Computer Science.
- co-Editor in Chief of the ARCoSS series of Springer Lecture Notes in Computer Science.
3.3.2 Algorithms and Data Science

The group of Algorithms and Data Science performs theoretical and applied research in the areas of algorithms and data science. There is particular interest in the design of algorithmic techniques for the analysis of very large volumes of data and for the economics of the internet, as well as in the algorithmic modeling of complex systems.

Research lines:

- Algorithms
- Data Science
- Big Data
- Algorithmic Game theory
- Mechanism Design
- Data Mining
- Social Networks
- Recommender Systems
- Economics and Computation
- Algorithmic Data Analysis
- Streaming
- Network and Stochastic Processes
- Random Structures

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

Post Docs: Adriano Fazzone, Chris Schwiegelshohn.

PhD Students: Giorgio Barnabò, Federico Fusco, Michele Gentili, Leonardo Martini, Cristina Menghini, Stefano Piersanti, Mara Sorella.

Projects:

- Algorithmic and Mechanism Design Research for Online Markets (AMDROMA), ERC Advanced Grant 2018 - 2023, S. Leonardi.
3.3.3 Artificial Intelligence and Knowledge Representation

Research lines:

- Description Logics
- Logics for AI
- Semantic Technologies
- Reasoning about Actions & Planning
- Spoken Language Understanding

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

Post Docs: Lorenzo Lepore, Marco Ruzzi, Valerio Santarelli, Domenico Fabio Savo.

PhD Students: Federico Croce, Federico Maria Scafoglieri, Marina Morelli, Gianluca Cima, Marco Favorito, Andrea Vanzo.

Other Collaborators: Giacomo Ronconi.

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 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 mu-calculus, ATL, LTL, LTL$^f$, and LDL$^f$; 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 and business processes over ontologies and data sources.

One specific application where knowledge representation has been applied is Spoken Language Understanding in the context of Robotics. Specifically, we have addressed the interpretation of spoken commands and the extension to handle more complex forms of dialog. The knowledge about the environment and the robot capabilities are used by the system in order to build the language that specifies robot commands. Moreover, the knowledge about the environment (semantic map), can be used to bias the interpretation of commands through a spoken language command interpretation chain that is based on statistical off-the-shelf tools.

Several group members are recipients of prestigious awards, are regularly involved in editorial activities of the scientific community, and are invited to deliver keynote talks at international conferences or workshops.

Awards and honours include: AAAI Fellowships: Maurizio Lenzerini, since 2017; Giuseppe De Giacomo, since 2016; Luigia Carlucci Aiello, since 1995; EurAI Fellowships: Riccardo Rosati, since 2016, Giuseppe De Giacomo, since 2012, Daniele Nardi, since 2009, Maurizio Lenzerini, since 2008; Luigia Carlucci Aiello, since 1999; Membership to the European Academy of Sciences and Arts (Luigia Carlucci Aiello, since 2005); ACM Fellowships (Maurizio Lenzerini, since 2009; Giuseppe De Giacomo, since 2016); Membership to the Academia Europaea –The Academy of Europe (Maurizio Lenzerini, since 2011); IJCAI Distinguished Service Award (Luigia Carlucci Aiello, 2009); ECAI Distinguished Services Award (Luigia Carlucci Aiello, 2014); Doctorate Honoris Causa (Luigia Carlucci Aiello, 2002, School of Technology, University of Linköping, Sweden); ACM Recognition Service Award (Maurizio Lenzerini, 2011).

Several group members are involved in various prestigious editorial activities: Giuseppe De Giacomo is Review Editor of Artificial Intelligence (Elsevier) and member of the Editorial Board of Acta Informatica, he is Vice-President of the Steering Committee Member of the International Conference on Principles of Knowledge Representation and Reasoning (KR), he is Area Chair of the 33rd AAAI Conference on Artificial Intelligence (AAAI 2019) and Senior Program Chair of 28th International Joint Conference on Artificial Intelligence (IJCAI 2018); Domenico Lembo is Vice-president of the Steering Committee Member of
the International Conference on Web Reasoning and Rule Systems (RR). Maurizio Lenzerini is Area Editor of Information Systems – An International Journal, for the area of Data Modeling and Knowledge Representation and Reasoning Techniques, Editorial Board member of Intelligenza Artificiale, The International Journal of the AI*IA, Area Editor of the Journal of Applied Logic for the area of Logic for Knowledge Representation and the Semantic Web, Editorial Board member of the Logical Methods in Computer Science (LMCS) Journal, for the areas of Database Theory and Logic for Knowledge Representation, and Area Editor of the Logic Journal of the Interest Group in Pure and Applied Logic (IJPL), for the area of Logic for Knowledge Representation and the Semantic Web, he has been co-Chair of the 29th International Workshop on Description Logics (DL 2016), since 2011 he is Member of the ACM SIGMOD Awards Committee, since 2006 he is Member of the Executive Committee of the ACM Principles of Database Systems (PODS), and since 2005 he is Member of the Sistemi Evoluti di Basi di Dati (SEBD) Steering Committee, he is also Member of the Scientific Advisory Board of BiCi – Bertinoro international Center for Informatics and Member of the Advisory Board of the European Research Institute in Service Science (ERISS).

Riccardo Rosati is Member of the Editorial Board of Artificial Intelligence (Elsevier), Steering Committee Member of the International Workshop on Nonmonotonic Reasoning (NMR), since 2012.

Finally, the following invited talks were delivered:

- Giuseppe De Giacomo, Foundations of Planning for LTLf and LDLf Goals, invited talk at Rice University Houston, TX, USA, January 31, 2018;

- Giuseppe De Giacomo, Reasoning About Actions: From Automata to LTLf/LDLf Synthesis and Planning invited PhD course at 17th Estonian Summer School on Computer and Systems Science Roosta Holiday Village, Estonia, August 19th-23th 2018

- Giuseppe De Giacomo, Reasoning and Planning for LDLf/LDLf goals, invited talk at the 33rd Italian Conference on Computational Logic. Bolzano, Italy, September 20-22, 2018;

- Giuseppe De Giacomo, Foundations for Restraining Bolts: Reinforcement Learning with LTLf/LDLf Restraining Specifications, invited talk at Rice University Houston, TX, USA, October 23, 2018;

- Domenico Lembo invited Lecturer on Data Integration at the EDBT 2017 summer school, Genoa, Italy, September 2017.

3.3 Engineering in Computer Science

Projects:

3.3.4 Artificial Intelligence and Robotics

Research lines:

- Artificial Intelligence and Robotics
- Robot Perception
- Cognitive Robotics
- Simultaneous Localization and Mapping
- Multi-Agent and Multi Robot Systems
- Semantic Knowledge for Robots
- Robot Competitions and Benchmarking
- Sensor Calibration
- Human-Robot Interaction
- Mobile Robot Navigation
- Robot Planning and Learning
- Social Robotics
- Reinforcement Learning
- Information Fusion
- Robot Security

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

Post Docs: Roberto Capobianco.


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 enable robots to perform complex tasks in a dynamic, unknown environment populated by other (robotic and human) agents. One section of the work
3.3 Engineering in Computer Science

aims at analyzing 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, emergency response robots, 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 Petri Net Plans, soccer robot vision applications (GNAO), IMBS, PHIS, PTracking, NICP, IMU-TK, D2CO, Easy-DepthCalibration, and the data sets data sets for maritime surveillance (MarDT), and the spoken language processing chain LU4R (in collaboration with Univ. Tor Vergata) and the 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:

- Prof. Mary Ellen Foster, University of Glasgow (UK), February - May 2018.

and foreign students:

- Ashley Oldershaw - University of Leeds (UK).
- Carlos Ibanez Cuadal - University of Barcelona (Spain).
- Liang Changhao - Nankai University (China).
- Zhang Jiashi - Nankai University (China).

Events (organized by the group):

• European RoboCupJunior 2018 Championship, Montesilvano (PE), Italy - May 29 - June 1, 2018.

• European RoboCup@Home Education 2018, Montesilvano (PE), Italy - May 29 - June 1, 2018.


Other activities:


• Luca Iocchi and Daniele Nardi have been members of the Board of Trustees of the RoboCup Federation, 2018.

• The SPQR team of humanoid soccer players participated in RoboCup 2018 Standard Platform League, Montreal Canada, obtaining the third place in the penalty kick challenge.

• The SPQReL team (joint team with University of Lincoln, UK) participated in RoboCup@Home 2018, Montreal Canada.

Projects:


• Flexsight (EU FP7, Experiment in ECHORD++), September 2016 - March 2018, A. Pretto, and D. Nardi.

• RockEU2 (Horizon 2020 programme), February 2016 - August 2018.

• SCIROC (Horizon 2020 programme), Agreement signed in 2017, the project will span through February 2018 - January 2022.

• Internet4All (MISE project), January 2017 - December 2018.

• Public Demonstrations of Social Robots in Public Environments - funded by Leonardo SPA, 2018.
3.3 Engineering in Computer Science

3.3.5 Computer Networks and Pervasive Systems

Research lines:

- Wireless and Sensor Networks
- Networks of Resource Constrained Devices
- Self-* Protocols and Systems
- People Centric Sensing
- Internet of Things
- Decentralized Applications
- Blockchain Technologies

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

PhD Students: Fabio Angeletti

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 the Internet of Things.

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 these context, interesting security and pri-
vacy issues emerge that due to the limited resources and the distributed nature of the ap-
plications, require the development of new techniques and algorithms. We complement
our research with an extensive 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).

More recently we have started a research activity on decentralized applications
and the employment of blockchain technologies to support the development of a new
distributed architectures beyond the classical client/server paradigm.
3.3.6 Cybersecurity

Research lines:

- Malware Analysis
- Security for cyber-physical systems
- Security governance
- Data privacy and security
- Threat intelligence


Post Docs: Marco Angelini, Claudio Ciccotelli, Emilio Coppa, Daniele Cono D’Elia, Francesco Liberati, Domenico Fabio Savo, Mara Sorella.

PhD Students: Luca Borzacchiello, Lorenzo Brigato, Roberto Germana’, Alessandro Giuseppi, Giuseppe Laurenza, Simone Lenti, Luca Massarelli, Simone Nicchi, Andrea Tortorelli.

The cybersecurity group is a multidisciplinary team of researchers that collates several knowledge areas and apply them to scientific problems in the context of IT security. The team works on several diverse topics related to cybersecurity, including:

Attack modeling — Among all the existing Attack models, Attack graphs represent a nice abstraction to capture the notion of multi-step attack i.e., an attack toward a specific target executed taking intermediate steps in which the attacker compromise several entireties and exploits their vulnerability to reach the target. Several attack graph representations exist in literature but they suffer the same limitation: they are poorly scalable and consider only vulnerability related to the underlying network infrastructure. We study how to improve the scalability of the attack graph generation process and how to enrich the attack graph with other types of information (e.g., application vulnerabilities, human vulnerabilities, etc.).

Binary similarity — Different works in literature afford the problem of binary similarity: given the binary code of two different functions they try to understand if these two binaries have been compiled from the same source. The problem has a large number of potential applications, but it is not trivial because the source code can be compiled with different compilers on different platforms, or the compiler can use different optimizations. We study how we can generalize this definition of similarity using deep learning. In particular, we aim at identifying semantic similarities among compiled functions to support malware analysis.
Blockchain — Blockchain is an emerging paradigm that allows to store data in a fully decentralized system guaranteeing data integrity and transparency in the data flow. Actually, several technologies exists that allows users to develop and deploy his/her own blockchain. We are studying issues related to blockchain scalability (in terms of achieved performance) and security against external attacks.

Cyber-physical systems — Protection and preventive control of cyber-physical systems via model-based control-theoretical approaches. Robust control and model predictive control are being utilized to safely operate complex systems, such as SCADA? controlled Critical Infrastructures (e.g., Power Networks), in order to assure service resilience and operational efficiency. On a related research line, we study novel solutions for the protection of IoT devices from external malicious interactions based on the behavioral analysis of the attacker.

Evasive malware — Sandboxes are a staple of modern malware detection and analysis techniques. However, malware writers over the years have adapted their strategies in order to have malicious sample hide their true colors when executing in such analysis environments. Fingerprinting techniques are employed to detect distinctive features of sandboxing products or even better of the virtualization technologies they rely upon. We investigate how dynamic binary instrumentation can be used to detect evasive attempts by malware samples, and fake the results provided by the execution environment in order to give a sample the illusion that it is executing in a non-hostile environment, or in a very specific hardware and software configuration in the case of APT malware.

Information Extraction for Open Source Intelligence — Open-Source INTelligence (OSINT) is intelligence based on publicly available resources, such as news sites, blogs, forums, social networks, etc. In OSINT, the Web is the primary source of information, and extracting, structuring and interpreting such information are crucial problem in many application scenarios, like, for instance, security, market intelligence, or statistics. We study how to transform raw information crawled from the Web into actionable data, by coupling traditional information extraction approaches with the use of semantic technologies, which may help to automatize this process and to assign a precise structure and a clear semantic to the extracted data.

Malware Analysis Support Tools — Understanding the behavior of malware requires a semiautomatic approach including complex software tools and human analysts in the loop. However, the huge number of malicious samples developed daily calls for some prioritization mechanism to carefully select the samples that really deserve to be further examined by analysts. This avoids computational resources be overloaded and human analysts saturated. We investigate a malware triage stage where samples are quickly and automatically examined to promptly decide whether they should be immediately dispatched to human analysts or to other specific automatic analysis queues, rather than following the common and slow analysis pipeline.
3.3  Engineering in Computer Science

Privacy Preserving Applications — Private computing provides a clever way to process data without revealing any details about the data itself to the party in charge of processing it. Data protection can be achieved by encrypting the signals and processing them in encrypted form. Possible applications of this approach are virtually endless. Among them, we explore privacy-preserving biometric matching, biomedical signal processing, private sensor fusion in IoT swarms, and private sample analysis for malware identification.

Return Oriented Programming — Code reuse attacks are exploits in which an attacker can execute arbitrary code on a compromised machine without having to inject it in memory, as they achieve the intended behavior by joining fragments of code belonging to a legitimate installed software component. Return oriented programming (ROP) attacks are the most common form of such attacks. We have been building a collection of ROP exploits of increasing complexity to foster their study in the research community; we also developed a tool for inspecting and analyzing how a ROP attack takes place, which can be sometimes a cumbersome task even for security professionals due to the entanglements of ROP code, and frequently an off-putting job for researchers. We are also exploring how code reuse can be employed in a defensive scenario, for instance to protect intellectual property in the context of code obfuscation and anti-piracy applications.

Swarm Attestation — Remote attestation protocols are widely used to detect device configuration (e.g., software and/or data) compromise in Internet of Things (IoT) scenarios. Unfortunately, the performances of such protocols are unsatisfactory when dealing with thousands of smart devices. Upon the recent concept of non-interactive attestation, we are approaching collective attestation problem by reducing it into a minimum consensus one and the results confirm the suitability of such solution for low-end devices, and highly unstructured networks.

Symbolic execution — In recent years symbolic execution has drawn considerable attention from academic and industrial researchers, with notable applications to, e.g., software testing, program verification, and security. We authored a survey of symbolic execution techniques, reviewing the state of the art in the design, implementation, and open research problems in the area, with particular attention to cybersecurity aspects. We have been researching in memory modeling problems for symbolic executors, proposing a model that can accurately capture pointer dereferencing operations, which are critical for instance in the detection of vulnerabilities (such as use-after-free and heap overflow) and in turn for their exploitation. We also explored how symbolic execution can help reconstruct the protocol used in Remote Access Trojans, which are weapons used by cybercriminals to control infected endpoints.

Visual analytics — Visual Analytics is the science of analytical reasoning facilitated by visual interactive interfaces. In the cyber-security domain it allows the human to manipulate and manage large quantities of data through powerful visual abstrac-
tions, supporting heterogeneous analysis tasks like monitoring, proactive and reactive analysis, what-if analysis and prediction. The support is at different levels, ranging from strategic decision processes down to active cyber-attacks countermeasures. We are actively studying novel visual analytics solutions for cybersecurity, focused on supporting proactive analysis of cyber-risk status for complex networks, real-time response to cyber attacks, effective explanation of learning process for malware classifiers, cybersecurity policy assessment and specification through standard frameworks (e.g. NIST cyber-security framework). Solutions regarding improving situational awareness of cyber-security operators under stressful situations and support to digital forensics activities are currently under development.

The cybersecurity group members are also strongly involved in the activities of the Research Center of Cyber Intelligence and Information Security (CIS). CIS does leadership applied 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:

- **ATENA, Advanced Tools to assEss and mitigate the criticality of ICT compoNents and their dependencies over Critical InfrAstructures** (managed by CRAT) - May 2016, April 2019 - EU MG H2020 Project, F. Delli Priscoli.


- **CyberChallenge.IT** 2018 - Industry-funded cybersecurity dissemination project, C. Demetrescu.

- **FILIERASICURA** (managed by CINI) - December 2016, December 2019 - Industrial project with CISCO and Leonardo, L. Querzoni.

- **EURASIA** - October 2016, October 2018 - Italy-Israel joint project, R. Baldoni.
3.3.7 Data Management and Service-Oriented Computing

Research lines:

- Data Integration and Exchange
- Ontology Based Data Management
- Data Warehousing, Data Quality and Data Cleaning
- Process and Workflow Management
- Service Modeling
- Service Synthesis and Composition


PhD Students: Simone Agostinelli, Gianluca Cima, Federico Croce, Lauren S. Ferro, Manuel Namici, Francesco Sapio, Federico Maria Scafoglieri.

Post Docs: Lorenzo Lepore, Valerio Santarelli.

Our interest in Data Management dates back to the '80s, when the main research topics addressed by our group were conceptual modeling and schema integration, now evolved into Information Integration and Data Exchange. Information integration is the problem of combining the data residing at different heterogeneous sources, and providing a virtual unified view of these data, called global schema, which can be queried by the users. Data Exchange focuses instead on the problem of materializing the global schema according to the data retrieved from the sources. Ontology-based data management (OBDM) is a promising direction for addressing the above challenges. The key idea of OBDM is to resort to a three-level architecture, constituted by the ontology, the sources, and the mapping between the two, where the ontology is a formal description of the domain of interest, and is the heart of the whole system. With this approach, the integrated view that the system provides to information consumers is not merely a data structure accommodating the various data at the sources, but a semantically rich description of the relevant concepts in the domain of interest, as well as the relationships between such concepts. Other Data Management topics related to Information Integration are also investigated, including View-based Query Processing, Data Warehousing, Data Quality, and Data Cleaning.

Our research interests include several aspects of Service-Oriented Computing, and its relationship with Data Management. Services in our context are autonomous, platform-independent computational elements that can be described, published, discovered, orchestrated and programmed for the purpose of developing distributed interoperable applications. We are particularly interested in service modeling and automatic service composition. In this area, we proposed what in the community is now known as the "Roman
model”, and contributing to one of the first solutions to automated service composition. Since its introduction, the Roman model has been studied by several research groups worldwide, and is one of the key references in the formal approaches to automated service composition. We have also studied Service Synthesis, as well as Process and Workflow Management, with a special focus on principles and techniques for modeling the interaction between processes and data.

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

(i) posing the semantics of the application domain at the center of the scene,

(ii) combining the management of data with the management of the processes and services using such data in the organization, and

(iii) shifting the role of the conceptual model from a design-time to a run-time artifact.

In our vision, the functionalities provided by the system include answering queries posed in terms of the conceptual model by suitably accessing the source data, performing updates over the conceptual models by invoking the appropriate updates on the sources, and realizing complex goals expressed by the client by automatically composing available services. The basic idea for realizing this goal is to combine principles, methods and techniques from different areas, namely, Data Management, Service-Oriented Computing, Knowledge Representation and Reasoning, and Formal Methods.

In 2018, members of the research group have been invited to organize various events, and to deliver keynote speeches at various conferences and workshops: Tiziana Catarci is the Editor-in-Chief of the ACM Journal of Data and Information Quality. In 2018 she has been Area chair of IEEE ICDE 2018 and General Chair of AVI 2018. Since 2016 she is member of the prestigious European Academy of Sciences and Arts. Since 2016 she has been included among the “100 Women for Science” project - [http://www.100esperte.it/] In 2018 she has been included among the “Inspiring-Fifty”,[https://italy.inspiringfifty.org/] the most influential women in the tech world. In 2018 she has been nominated fellow of the EAI - European Alliance for Innovation. She is the co-EiC of the EAI Transactions on Ambient Systems. She is in the Editorial Board of the WWW Journal and in the Editorial Board of the Journal on Data Semantics.

Domenico Lembo is Vice-presidente of the Steering Committee of the International Conference on Web Reasoning an Rule Systems (RR).

Maurizio Lenzerini is Area Editor of Information Systems - An International Journal for the area of Data Modeling and Knowledge Representation and Reasoning Techniques, 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, Area Editor of Journal of Applied Logic for the area of Logic for Knowledge Representation and the Semantic Web, in the Editorial Board of the LMCS - Logical Methods in Computer Science, for the areas of Database theory and Logic for knowledge representation, in the Editorial Board of Big Data Research, Elsevier, in the Editorial Board of Intelligenza Artificiale, The International Journal of the AI*IA. He was in the Senior Program Committee of the the 27th International Joint Conference on Artificial Intelligence and the 23rd European Conference on Artificial Intelligence, IJCAI-ECAI 2018, in the Program Committee of the Thirty-second AAAI Conference on Artificial Intelligence, AAAI 2018, in the Program Committee of the RuleML+RR: International Joint Conference on Rules and Reasoning, RuleMLRR 2018, in the Program Committee of the XIII National Conference on Statistics, 2018, in the Program Committee of the The First IEEE International Conference on Artificial Intelligence and Knowledge Engineering, AIKE 2018. Since 2005 he is Member of the Sistemi Evoluti di Basi di Dati (SEBD) Steering Committee; He is also Member of the Scientific Advisory Board of BiCi –Bertinoro international Center for Informatics, and Member of the Advisory Board of the European Research Institute in Service Science (ERISS).

Andrea Marrella is Information Director of the ACM International Journal on Data and Information Quality (ACM JDIQ), and Associate Editor (Editorial Board Member) of the International Journal of Information Systems for Crisis Response and Management (IJISCRAM). He has been selected as Expert Reviewer for the grant of Natural Science and Engineering Research Council of Canada - Discovery Grants Program (NSERC).

Massimo Mecella was General Chair of the 14th International Conference on Intelligent Environments, IE 2018.

Finally, Antonella Poggi was Invited Speaker at the 13th Conferenza Nazionale di Statistica.

Projects:

- “Ontology-based data management for health-related quality of life of thyroid cancer patients”. Project funded by Sapienza. The project will end in 26/02/2022.
- PRE-O-PRE - “PREserving Open data while opening PREserved data”. Research project funded by Sapienza. The project will end in 31/10/2019.
- MODEUS - “Making Open Data Effectively USable”. SIR research project funded by MIUR, grant n. RBSI14TQHQ. The project will end in 03/2020.
- “Design and Maintenance of Ontology-Based Data Access Systems”. Research project funded by Sapienza. The project will end in 31/12/2019.
- Research project funded by MIUR under FFABR (Fondo di Finanziamento per le Attività Base di Ricerca). The project will end in 31/12/2018.
• “FIRST”. Research project funded by H2020 RISE. The project will end in 31/12/2020.

• “Fustella 4.0”. Research project funded by Rota Laser Dies S.r.l.. The project will end in 31/12/2019.

• “EcoDigit”. Project funded by Centro Eccellenza Distretto Beni Culturali Regione Lazio. The project will end in 25/01/2020.
3.38 Distributed Systems

Research lines:

- Secure and robust distributed systems
- Fog Computing
- Theoretical Aspects of DLTs
- Event-based Systems
- Stream processing systems
- Resource Sharing Systems
- Smart Environments
- Distributed Systems Interoperability

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

PhD Students: Giovanni Farina.

Post Docs: Claudio Ciccotelli, Antonella Del Pozzo.

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, malware analysis, 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:

- **FILIERASICURA** - December 2016, December 2019 - Industrial project with CISCO and Leonardo.

- **EURASIA** - October 2016, October 2018 - Italy-Israel joint project.
3.3.9 High Performance and Dependable Computing Systems

Research lines:

- Parallel and Distributed Computing Platforms
- Operating Systems
- High Performance Computing
- Multi-core Programming
- Multi-tier Architectures
- Transactional Systems
- Virtualization and Cloud Computing
- Non-blocking/Wait-Free Algorithms
- Software Instrumentation and Compiling Techniques
- Software Reversibility on Non-Reversible Systems
- Performability Models
- Heterogeneous Computing

Members: Bruno Ciciani (leader)

Post Docs: Pierangelo Di Sanzo, Alessandro Pellegrini.

PhD Students: Davide Cingolani, Simone Economo, Mauro Ianni, Romolo Marotta, Stefano Conoci, Emiliano Silvestri, Stefano Carnà.

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 design and implementation of transparent middleware-level software to enable software reversibility on top of non-reversible hardware, as a building block to optimize execution of data-intensive applications and/or enable post-mortem reversible debugging.

- 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 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:


3.3 Engineering in Computer Science

3.3.10 Human-Computer Interaction

Research lines:

- User Interfaces
- Usability Engineering and Accessibility
- Information Visualization and Visual Analytics
- Automated Personalization and Adaptation in Web-based Learning
- Web-based Social Collaborative Learning
- Game-based Technology-Enhanced Learning

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

Post Docs: Marco Angelini, Andrea Marrella, Francesco Leotta

PhD Students: Graziano Blasilli, Lauren Ferro, Simone Lenti, Francesco Sapio, Mahmoud Sharf

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, technology-enhanced 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.

**Scientific roles:**

- Tiziana Catarci is Editor in Chief of EAI Transactions on Ambient Systems.
- Tiziana Catarci since 2016 she is member of the prestigious European Academy of Sciences and Arts.
- Tiziana Catarci since 2016 she has been included among the “100 Women for Science” project - http://www.100esperte.it/.
- Tiziana Catarci in 2018 has been included among the “InspiringFifty”, https://italy.inspiringfifty.org/ , the most influential women in the tech world.
- Tiziana Catarci in 2018 she has been nominated fellow of the EAI – European Alliance for Innovation.
- Giuseppe Santucci is in the Steering Committee of IEEE Conference on Visual Analytics Science and Technology - VAST
- Giuseppe Santucci is in the Steering Committee of EG/VGTC Conference on Visualization - EUROVIS
- Giuseppe Santucci is in the Program Committee of EG/VGTC Conference on Visualization - EUROVIS
- Giuseppe Santucci is in the Program Committee of IEEE Conference on Visual Analytics Science and Technology - VAST
• Giuseppe Santucci is in the Steering Committee of ACM International Workshop BEyond time and errors: novel evaLuation methods for Information Visualization BELIV

• Giuseppe Santucci is Workshop & Tutorial Chair in the conference Advanced Visual Interfaces AVI

• Massimo Mecella is general chair of International conference of Advanced Visual Interfaces (AVI) 2018

• Marco Temperini is Associate editor in the journal IJDET (Int. Journal on Distance Education Technology, https://www.igi-global.com/journal/international-journal-distance-education-technologies/1078).

• Marco Temperini is member of the Steering Committee of the workshop IEE-TEL (Int. workshop on Interactive Environments and Emerging Technologies for eLearning, https://sites.google.com/view/ieetel2019).

• Andrea Marrella is the Poster & Demo Chair of 14th International Conference on Advanced Visual Interfaces (AVI 2018)

• Francesco Leotta is Poster & Demo Chair for Intelligent Environments 2018

• Marco Angelini was co-chair of ITA.WA, 1st Italian workshop on Advanced Visualizations and Visual Analytics, co-located at AVI 2018

Projects:

• NEPTIS - January 2015 – March 2018 – Italian PON (PON03PE_00214)

• IT-SHIRT - 2018 – 2020 – Sapienza project

• METRICS - 2018 – Sapienza project

• 9 Conversations: Network building for self-employment of refugees - 2018 —2020 Erasmus+ Programme, Key Action 2

• NOTAE ERC-2017-ADG project NOTAE (N°786572)
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 Annarelli, Alessandro Avenali, Giuseppe Catalano, Tiziana D’Alfonso, Rosa Maria Dangelico, Cinzia Daraio, Luca Fraccascia, Domenico Laise, Claudio Leporelli, Riccardo Marzano, Giorgio Matteucci, Alberto Nastasi, Fabio Nonino, Pierfrancesco Reverberi.

Post Docs: Mirko Giagnorio.

PhD Students: Martina Gregori, Giulia Palombi, Alessandro Pompei, Luigi Scuncio.

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.
3.4 Management Engineering

- **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:

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


- 2017-2018: Sapienza Research Awards no. (C26N15TJLN) Methods and procedures for the determination of standard costs in the local public bus transport sector;

- 2017-2019: Sapienza Research Awards, Green innovation in family firms: drivers, characteristics, and success factors;

- 2017-2019: Sapienza Research Awards, Methods and procedures for the allocation of national public resources in the Italian local public transport sector;


- Research infrastructures for the assessment of science, technology and innovation policy (RISIS), Grant agreement No. 313082 project of the EU FP7 Research Program;

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).

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

The activity of the Combinatorial Optimization Group at DIAG dates back to the early '90s and has been focused both on the theoretical properties of combinatorial structures and the use of sophisticated algorithmic tools to solve real-life problems. In particular, major research has been carried out on the following subjects: polyhedral properties of set covering, stable set and p-median problems; perfect graph theory, exact and heuristic algorithms for stable set and set covering; algorithms for coloring and frequency assignment problems; decomposition algorithms and reformulations for wireless network design problem; fixed network design and survival network design; algorithms for job-shop scheduling and railway traffic management; algorithms for satisfiability of logic formulae, algorithms for information reconstruction in large datasets, algorithms for classification based on propositional logic, algorithms for inconsistency selections.

The group is currently cooperating with the University of Maastricht, University of Oslo, Università di Roma Tor Vergata, Università dell’Aquila, Università di Lecce, Politecnico di Milano, Università del Sannio, Istituto Nazionale di Statistica (Istat), Texas Tech University, ZIB Berlin. The group has been involved in a large number of national and international projects. In the last 10 years the group has developed methods and algorithms aimed at the optimal design of broadcasting networks. The scientific leadership gained in this field has motivated a stable cooperation with the Italian Authority for...
Telecommunication and the decisive contribution of the group to the design of the national (analog and digital) TV and radio plans.

The current key members of the group have published more than 100 journal papers, several book chapters, and two books. Moreover they are or have been editors of some of the main journals in the field of Operations Research and Optimization. Recently the group received a prestigious international award from the Association of European Operational Research Societies (EPA 2009). In addition to further development of on-going research project, our future activities involve the study of optimization algorithms to rescue or prevent financial crises and for portfolio management; algorithms for weighted matching and stable set problems; polyhedral properties of the stable set polyhedron and of interval and staircase matrices; optimization techniques for classification problems in machine learning; purely combinatorial approaches to wireless network design; railway traffic control and optimization on single-track networks.

Projects:


- APICE - Algoritmi per la Pianificazione Integrata e Controllo di reti wireless Etero-genee, progetto MIUR n. 2878, R. Bruni.
3.5 Operations Research

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

PhD Students: Marco Boresta, Tommaso Colombo, Annalivia Croella, Danny D’Agostino, Tommaso Giovannelli, Giorgio Grani, Francesco Romito, Ruggiero Seccia, Edoardo Maria Tronci.

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.
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: Francesco Delli Priscoli (co-leader) and Antonio Pietrabissa (co-leader), Alessandro Di Giorgio, Alberto Isidori (emeritus).

Post Docs: Silvia Canale, Federico Cimorelli, Andrea Fiaschetti, Francesco Liberati, Martina Panfili, Lorenzo Ricciardi Celsi, Vincenzo Suraci.

PhD Students: Roberto Germanà, Alessandro Giuseppi, Federico Lisi, Antonio Ornatelli, Andrea Tortorelli.

The networked systems area has developed, in the last 18 years, thanks to the successful participation in 38 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 participated 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 (derived 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). To deal with the above-mentioned vision, the networked systems area deals with the following key enablers: model-free learning, multi-agent systems 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:


- **ATENA, Advanced Tools to assEss and mitigate the criticality of ICT compoNents and their dependencies over Critical InfrAstructures** (managed by CRAT) - May 2016, April 2019 - EU MG H2020 Project, F. Delli Priscoli.

- **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 DS H2020 Project, F. Delli Priscoli.

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).

Post Docs: Mattia Mattioni.

PhD Students: Massimiliano D’Angelo, Mohamed Elobaid, Alessio Moreschini.

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. Stabilization of nonlinear systems with control and measurement delays. Global state estimators for systems with delays. State estimators and optimal control for noisy systems with non-Gaussian noise and packet loss. Stochastic delay identification. Analysis and design of real control systems integrating devices and computational procedures in a digital context involves ad-hoc methods. Nonlinear discrete-time and sampled data systems are the subjects of an investigation developed at La Sapienza from the early 80s, in a still active cooperation with the Laboratoire des Signaux et Systèmes of the French CNRS. The research activity has been focused on solving nonlinear control problems in discrete-time and on finding digital solutions to continuous-time control systems. One of the major outcome of the investigation has been the settlement of an original approach, mixed by algebraic and geometric concepts, used either to prove the existence of solutions in discrete-time or to compute approximated solutions in the digital context. Two aspects are at the bases of the more recent developments: a new representation of discrete-time dynamics, which provides a natural framework for comparing results from the continuous-time and discrete-time contexts, the concept of exact sampled model under feedback, which can be used to design piecewise continuous controllers in a direct digital context. From the solution to feedback linearization, stabilization, regulation, observer theory, new research lines are in the direction of Lyapunov and passivity based design, inverse optimal control and time delayed systems in discrete-time and under sampling. Particular attention is devoted to the settlement of executable algorithms for computing the proposed solutions. 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 Hamiltonian dynamics and 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, the distributed data handling, multi-consensus, load balancing, and quality of experience evaluation and control 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. Prof. Monaco is member of the Conseil exécutif and of the Conseil stratégique of the Università Italo Francese and coordinator of the double degree in collaboration with the Stic & A Network of French Universities.
The applicative aspects of the research activities are carried out at the Systems and Control Laboratory, founded in 1995.

Projects:


- *Modellizzazione e controllo del sistema glicemia-insulinemia in pazienti con diabete di tipo I*, progetto di Ateneo, C. Califano.

- *Sistemi complessi in rete in presenza di ritardi*, Progetto C4-367 Bando Vinci 2018 dell’Università italo-francese UIF/UFI
3.6 Systems and Control Engineering

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.

Post Docs: Massimo Cefalo, Marco Cognetti, Claudio Gaz, Emanuele Magrini, Valerio Modugno.

PhD Students: Khaled Al Khudir, Barbara Barros Carlos, Daniele De Simone, Paolo Ferrari, Marco Ferro, Maram Khatib, Nicola Scianca, Spyridon Tarantos, Giulio Turrisi.

The Robotics group at DIAG, and the associated DIAG Robotics Lab, 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 collaboration; sensory supervision of human-robot interaction.

Most of our research activities undergo experimental validation in the DIAG Robotics Lab. The current equipments consist of three articulated manipulators (a 6R Universal Robots UR10, a 7R lightweight KUKA LBR4+ with FastResearchInterface, and a 6R KUKA KR5 industrial robot), two haptic interfaces with 3D force feedback (Geomagic
Touch), 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 (3 NAO humanoid robots by Aldebaran), 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, and stereo vision systems. We have multiple RGB-D sensors, two 6D F/T sensors (Mini45 by ATI), and a HMD (Oculus Rift). We also have a sensorized platform (Cyberith Virtualizer) for locomotion and VR immersion. In the past, we have designed and built a two-link flexible manipulator (FlexArm) and a differentially-driven wheeled mobile robot (SuperMARIO).

Projects:


4 Publications

Biomedical Engineering

Bioengineering and Bioinformatics

Journal Papers


Conference Proceedings


Other (Technical Reports, Submitted Papers, etc.)


Economics

Innovation, Internationalization and the Environment

*Journal Papers*


Engineering in Computer Science
Algorithm Design and Engineering

Journal Papers

Conference Proceedings

Other (Technical Reports, Submitted Papers, etc.)

Algorithms and Data Science

Journal Papers


Conference Proceedings


Articles in Books


Other (Technical Reports, Submitted Papers, etc.)


Artificial Intelligence and Knowledge Representation

Journal Papers

Conference Proceedings


Articles in Books


Other (Technical Reports, Submitted Papers, etc.)


Artificial Intelligence and Robotics

Journal Papers


Conference Proceedings


Articles in Books


Other (Technical Reports, Submitted Papers, etc.)


**Computer Networks and Pervasive Systems**

**Journal Papers**


**Conference Proceedings**


**Cybersecurity**

**Journal Papers**


Conference Proceedings


**Articles in Books**


**Other (Technical Reports, Submitted Papers, etc.)**


**Data Management and Service-Oriented Computing**

**Journal Papers**


**Conference Proceedings**


Articles in Books


Other (Technical Reports, Submitted Papers, etc.)


Distributed Systems

Journal Papers


Conference Proceedings


Other (Technical Reports, Submitted Papers, etc.)


High Performance and Dependable Computing Systems

Conference Proceedings


Human-Computer Interaction

Journal Papers


Conference Proceedings


**Articles in Books**


Di Mascio, T., P. Vittorini, R. Gennari, F. De la Prieta, S. Rodriguez, M. Temperini, R. A. Silveira, E. Popescu, and L. L. (Eds.) Proc. 8th Int. Conference Methodologies and Intel-


Other (Technical Reports, Submitted Papers, etc.)


Management Engineering

Industrial Organization and Management

Journal Papers


Conference Proceedings


Articles in Books


Operations Research

Combinatorial Optimization

Journal Papers


Continuous Optimization

Journal Papers


Conference Proceedings


**Articles in Books**


**Other (Technical Reports, Submitted Papers, etc.)**


Systems and Control Engineering

Networked Systems

Journal Papers


Conference Proceedings


Other (Technical Reports, Submitted Papers, etc.)


Nonlinear Systems and Control

Journal Papers


**Conference Proceedings**


**Articles in Books**


Other (Technical Reports, Submitted Papers, etc.)


Iacoviello, D. “Physiological Cybernetics: Methods and Applications”. To Appear in New Developments on Computational Methods and Imaging in Biomechanics and Biomedical Engineering. 2019.


Robotics

Journal Papers


Conference Proceedings


Other (Technical Reports, Submitted Papers, etc.)


