Dipartimento di Ingegneria Informatica, Automatica e Gestionale Antonio Ruberti

Via Ariosto 25, 00185 Roma

www.diag.uniroma1.it

Research Report 2024

Dipartimento di Ingegneria Informatica, Automatica e Gestionale Antonio Ruberti

DIPARTIMENTO DI INGEGNERIA INFORMATICA, AUTOMATICA E GESTIONALE ANTONIO RUBERTI

DIAG Report

SAPIENZA
UNIVERSITÀ DI ROMA

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

DIAG Report 2024

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1 Introduction

The present document is a report about the research and dissemination activities carried out in 2024 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, control, and management sciences and engineering. 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 in information technologies, automation, and management, either in universities or in industries. The faculty of DIAG in 2024 consists of 49 full professors, 41 associate professors, and 41 assistant professors (ricercatori). They teach undergraduate and graduate courses in several programs of the two Engineering schools at Sapienza (Facoltà di Ingegneria dell'Informazione, Informatica e Statistica and Facoltà di Ingegneria Civile ed Industriale) and in the Master in Product Design of the School of Architecture (Facoltà di Architettura). Details about teaching activities are not reported in this document; a description may be found at http://www.diag.uniroma1.it, under the section "Teaching". DIAG offers also four PhD programs, and cooperates with other PhD programs. They are briefly described in Section 2.4 of this report.

Research activities at DIAG are organized in six areas, each composed by one or more research groups.

An overview of each group is reported in Section 3, together with the list of people involved in 2024.

2 General Information

2.1 Location

DIAG is located in 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 Monday to Friday 8.30 - 19.30, Saturday 9:00 -13:00. There are two reading rooms available for students, for a total of 87 places. Library facilities are available also to students and faculty members of other departments and universities. In addition to other librarian activities, conferences on specific topics and book presentations are organized. The staff supports also in the insertion and verification of research products of DIAG faculty members in the IRIS database of Sapienza

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
Research at AlcorLab covers topics of Computer Vision, Pattern Recognition, Deep Learning, Multimedia Analysis and Edge Computing.
Web: http://www.diag.uniroma1.it/alcor Head: Marco Schaerf

BiBiLab - Bioengineering and Bioinformatics Laboratory

Via Ariosto 25 - basement
The laboratory aims to develop interdisciplinary methodologies by integrating diverse fields, such as signal processing, computer science, systems science, and statistics applied to medical and biological sciences, specifically including:

modeling of metabolic systems, information processing from raw molecular biological data to solve interesting biological and medical problems, non-invasive estimation of the electrical activity and functional connectivity of the human brain, development of brain-computer interfaces for assistive and rehabilitation purposes. Head: Laura Astolfi

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. Head: Maurizio Lenzerini

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 Head: Giuseppe Oriolo

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.
Head: Paolo Di Giamberardino

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://diag.uniroma1.it/nclab/ Head: Francesco Delli Priscoli

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: Giuseppe Santucci

ROCOCO - 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://labrococo.diag.uniroma1.it/ Head: Daniele Nardi

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.

2.3 People

Head of department: Tiziana CATARCI and from November 1st 2024 Alberto Nastasi
Administration head: Fabio TUFILLI

Professors

Aris ANAGNOSTOPOULOS
Laura ASTOLFI
Giorgio AUSIELLO (*professor emeritus*)
Alessandro AVENALI
Stefano BATTILOTTI
Luca BENVENUTI
Sara BERNARDINI
Tiziana CATARCI
Ioannis CHATZIGIANNAKIS
Febo CINCOTTI
Francesco COSTANTINO
Idiano D'ADAMO
Cinzia DARAIO
Giuseppe DE GIACOMO
Alessandro DE LUCA
Francesco DELLI PRISCOLI
Gianni DI PILLO (*professor emeritus*)
Francisco FACCHINEI
Lorenzo FARINA
Antonio FRANCHI
Giorgio GRISETTI
Luca IOCCHI
Alberto ISIDORI (*professor emeritus*)
Domenico LEMBO
Maurizio LENZERINI

Associate professors

Irene AMERINI
Pietro ARICO'
Luca BECCHETTI
Roberto BERALDI
Silvia BONOMI
Renato BRUNI
Claudia CALIFANO
Marco CONSOLE
Andrea CRISTOFARO
Tiziana D'ALFONSO

Stefano LEONARDI
Pietro LIò
Stefano LUCIDI
Alberto MARCHETTI-SPACCAMELA
Massimo MECELLA
Salvatore MONACO
Umberto NANNI
Daniele NARDI
Alberto NASTASI
Roberto NAVIGLI
Fabio NONINO
Giuseppe ORIOLO
Laura PALAGI
Chiara PETRIOLI
Veronica PICCIALLI
Leonardo QUERZONI
Pierfrancesco REVERBERI
Riccardo ROSATI
Giuseppe SANTUCCI
Marco SCHAERF
Marco SCIANDRONE
Fabrizio SILVESTRI
Marilena VENDITTELLI
Ivan VISCONTI

Fabrizio D'AMORE
Alberto DE SANTIS
Paolo DI GIAMBERARDINO
Alessandro DI GIORGIO
Giuseppe Antonio DI LUNA
Francesca DI PILLO
Luca FRACCASCIA
Fabio FURINI
Nicola GALESI
Daniela IACOVIELLO

Leonardo LANARI
Riccardo LAZZERETTI
Francesco LIBERATI
Paolo LIBERATORE
Giampaolo LIUZZI
Andrea MARRELLA
Riccardo MARZANO
Giorgio MATTEUCCI
Mattia MATTIONI
Christian NAPOLI
Paola PACI
Fabio PATRIZI
Antonio PIETRABISSA
Antonella POGGI
Massimo ROMA
Simone SAGRATELLA
Saverio SALZO
Marco TEMPERINI
Jlenia TOPPI
Andrea VITALETTI

Assistant professors (ricercatori)

Simone AGOSTINELLI
Nicola ALTAMURA
Alessandro ANNARELLI
Ala ARMAN
Federica BACCINI
Edoardo BARBA
Piercosma BISCONTI
Graziano BLASILLI
Johannes BRUSTLE
Thomas Alessandro CIARFUGLIA
Gianluca CIMA
Silvia COLABIANCHI
Emma COLAMARINO
Simone CONIA
Chiara CONTI
Anna Livia CROELLA
Daniele Cono D'ELIA
Emanuele DE SANTIS
Simone DI LEO
Valerio DI VIRGILIO
Valerio DOSE
Giulia FISCON
Federico FUSCO
Mirko GIAGNORIO
Alessandro GIUSEPPI
Martina GREGORI
Chiara GROSSO
Simone LENTI
Francesco LEOTTA
Eugenio OROPALLO
Manuela PETTI
Gabriele PROIETTI MATTIA
Giulio RIGONI
Paolo RUSSO
Federico Maria SCAFOGLIERI
Nicola SCIANCA
Federico SICILIANO
Antonio Maria SUDOSO
Giovanni TRAPPOLINI
Elena UMILI
Marco ZECCHINI

Post doc (research associates) and research assistant

Giorgio BARNABÒ
Davide BAZZANA
Simone BOESSO
Maria Sofia BUCARELLI
Cesare CAMPAGNANO
Davide CAPOZZI
Massimiliano D'ANGELO
Valeria DE SETA
Luca DI GIAMMARINO
Paolo FERRARI

Marco FERRO
Simone FIORAVANTI
Benedetta GAMBOSI
Emanuele GIACOMINI
Emanuele GIONA
Giordano LAURENZI
Agnese MACORI
Luca MAIANO
Danilo MENEGATTI
Marta MONACI
Flavia MONTI
Lorenzo PORCARO
Maria Grazia PUXEDDU
Vincenzo RONCA
Valeria RUSCIO
Francesco SAPIO
Olga SOROKOLETOVA
Andrea TORTORELLI
Luigi VONA
Andrea WRONA

Administration staff

Salvatore BARBIERI
Adriano BENASSI
Antonella CANCELLIERI
Federica CANNELLI
Ugo CINELLI
Sara CIOTTI
Alberta DEL PUNTA
Andrea DORI
Stefano FIORUCCI
Sabrina GIAMPAOLETTI
Domeniko KOLZIU
Domenico MACARI
Giulia OLIVIERI SANGIACOMO
Marcello PANI
Alessia POLCINO
Roberta PROIETTI SEMPRONI
Francesco SPOGNARDI
Tiziana TONI
Fabio TUFILLI
Fulvio VALENTE
Concetta VELLA
Alessandra VERBENA

2.4 Doctoral programs

DIAG offers the two PhD programs in Automatic Control, Bioengineering and Operations Research and in Engineering in Computer Science, hosts a section of the national doctorate program in Artificial Intelligence, and cooperates with the PhD program in Data Science offered by another department.

Automatica, Bioingegneria e Ricerca Operativa (ABRO)

Coordinator: Laura Palagi

L'obiettivo formativo del dottorato in Automatica, Bioingegneria e Ricerca Operativa (ABRO) è quello di preparare giovani studiosi a gestire realtà complesse attraverso l'adozione di strumenti modellistici, l'impiego di metodi di analisi di modelli e processi nonché lo sviluppo di tecniche di progetto e implementazione su sistemi reali nei diversi ambiti applicativi.

PhD students

XXXVI course

BELVEDERE Tommaso
CALAMITA Alice
CIPRIANO Michele
D'ONOFRIO Federico
MENEGATTI Danilo
MEROLLA Davide
MONACI Marta
TANTUCCI Andrea
WRONA Andrea

XXXVII course

BRILLI Andrea
COPPOLA Corrado
D'AVINO Arcangelo
MARIOSA Raffaele
MONGIARDINI Elena
PATRIA Daniele
PIERMARINI Christian
PRIORI Gianluca
PUSTINA Pietro
ZUBAIR Muhammad

XXXVIII course

BALDISSERI Federico
D'ORAZIO Francesco
GIANCOLA Francesca
GOVONI Lorenzo
MAIANI Arturo
PANNONE Alessandro
QUATTROCIOCCHI Ilaria
RANIERI Andrea
SASSO Valerio
SCARPONI Giulio

MENCHETTI Marco

XXXIX course

ATANASIOUS Mohab
BECCHETTI Valentina
CARACCI Valentina
CESARONI Edoardo
CICCARELLI Fabio
GERMANO Daniele
HABIB Andrew
MAJI Atanu
PALA Anna Laura
PATARINI Francesca
RICCARDI Giulia
SAVINA Giulia

Cybersecurity

Coordinator: Leonardo Querzoni

Cybersecurity today represents a rapidly growing research area with important multidisciplinary aspects, ranging from purely technological issues to aspects related to the control of data and information flows in complex socio-technical scenarios such as healthcare, e-government, digital business, finance, logistics and energy. Cybersecurity also offers a promising research field to advance theoretical knowledge in disciplines such as computing, information systems, management, innovation, regulation and strategy. The research topics of interest for the PhD include: system security, software, hardware and network security, cryptography, cyber risk management, data security and privacy, security governance, supply chain security, opsec, economics of cybersecurity, high reliability organizations, disinformation.

PhD students
XXXVI course

BARDHI Enkeleda

XXXVIII course

ARDITO Stefania
DI PIETRO Giorgia
ENNAJI Sabrine
FACCIOLO Lisa
MARINI Matteo
NESTA Francesco
NOTARISTEFANO Maria
PRIAMO Giacomo

XXXIX course

DELLA MONICA Pierpaolo
GABRIELLI Edoardo
PICCARDO Giorgio
REALE Andrea

LORU Edoardo
MAZZINI Pietro
RUGGIERO Claudia

Data Science

Coordinator: Fabrizio Silvestri

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 economicsocial 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:

- Advanced digital platforms,
- Management of urban spaces and environmental resources
- Medicine and health
- Economic and Social Analysis.

PhD students

XXXVI course

ABRATE Carlo
BUCARELLI Maria Sofia
CINUS Federico
DENNI Riccardo
GIUSTI Lorenzo
SICILIANO Federico

XXXVII course

BENEDETTI Roberto
CASSARA Giulia
DI GIOVENALE Stefano
FUSO Federica
GEBRETENSAE Yacob Tsegay
LAURENTI Laura
ONORATI Andrea
PEZONE Francesco
SAMPIERI Alessio
SCOFANO Luca
TELYATNIKOV Lev
TESTA Lucia

XXXVIII course

BAIOCCHI Alessandro
GUERRA Marco

CASO Francesco
CECCARONI Riccardo
DE CARLO Gianluca
DEVOTO Alessio
FERILLI Marco
FIORELLINO Simone
GIOIA Matteo
JIMENEZ GUTIERREZ Daniel Mauricio
LENTI Jacopo
PAWLOWSKI Michal
POMARO Angela
RUSSO Matteo
SAURIO Gaetano
VERDINI Francesco

XXXIX course

BETTI Martina
DI FRANCESCO Andrea Giuseppe
FIANDRINO Stefania

Dottorato nazionale in Intelligenza Artificiale

Coordinator: Maurizio Lenzerini

Il Dottorato Nazionale in Intelligenza Artificiale (Phd-AI.it) riguarda un tema centrale per la trasformazione digitale della società. Ha l'obiettivo di mobilitare la comunità nazionale per un dottorato in AI al più alto livello scientifico, tale da dare impulso alla ricerca e all'innovazione industriale e sociale del paese. Il PhD-AI.it si attua, con il coordinamento del CNR e dell'Università di Pisa, con l'istituzione di 5 dottorati in AI federati, organizzati da un'università capofila e da un ampio consorzio di università ed enti di ricerca. I dottorati hanno una base comune focalizzata sugli aspetti fondazionali dell'AI e 5 aree di specializzazione:

- Sicurezza e cybersecurity, Sapienza Università di Roma
- Salute e scienze della vita, Università Campus Bio-Medico di Roma
- Agrifood e ambiente, Università di Napoli "Federico II"
- Industria 4.0, Politecnico Torino
- Società, Università di Pisa.

PhD students

XXXVII course

BACCIU Andrea
CAPOZZI Gianluca
CAPPELLINI Guglielmo
MATHEW Jerin George
RAGNO Alessio
SCIRè Alessandro

XXXVIII course

ARGENZIANO Francesco
DELFINO Roberto Maria
PARRETTI Gianmarco

XXXIX course

ANDRADE NEVES Pedro Jorge
BRIGLIA Maria Rosaria
FIANI Francesca
FILOSA Matteo
GENOVESE Donatella

Ingegneria Informatica

Coordinator: Roberto Navigli

Il titolo di Dottore di Ricerca (Ph.D.) rappresenta il più alto livello nella formazione accademica. Il corso di Dottorato in Ingegneria Informatica offerto dall'Università di Roma La Sapienza ha lo scopo di fornire le competenze necessarie allo svolgimento di attività di ricerca altamente specializzata in diversi campi dell'Ingegneria Informatica e termina con la stesura di un lavoro di tesi.
I settori di principale interesse del Dottorato in Ingegneria Informatica sono:

- Architetture, sistemi di elaborazione e reti di calcolatori
- Ingegneria degli algoritmi ed analisi di complessità
- Ingegneria del software
- Intelligenza artificiale e rappresentazione della conoscenza
- Intelligenza artificiale e robotica
- Sistemi informativi
- Basi di dati
- Sistemi distribuiti
- Software orientato ai servizi
- Web e reti sociali
- Cyber security & intelligence
- Computer vision & computer graphics
- Interazione persona-calcolatore
- Sistemi multi-agente e Sistemi multi-robot

PhD students

XXXVI course

ALATI Edoardo
BORZACCHIELLO Luca
BRIGATO Lorenzo
CARBONE LORIO Carlos Salvador
FAWAKHERJI Mulham

XXXVII course

BERNASCONI Eleonora

GUADAGNINO Tiziano

XXXVIII *course*

ARTUSO Fiorella
BAZZANA Barbara
BENVENUTI Dario
BRANDIZZI Nicolo'
BRUNORI Damiano
CARELLO Maria Patrizia
CONSOLE Francesca
CUOCI Marco
DI GIAMMARINO Luca
DI RETO Emiliano
GRAZHDANKIN Mikhail
KASZUBA Sara
PIMPINI Adriano
SURIANI Vincenzo
VENERUSO Silvestro V.

XXXIX *course*

ALTAMURA Nicola
ASSAIANTE Cristian
BATOOL Aiza
BOTTURA Nicola
BRIZI Leonardo
CIABATTI Giulia
DE MAGISTRIS Giorgio
FAZZINI Paolo
FICARRA Giovanni
FRATTOLILLO Francesco
GBAHOU Davy Yann
GIACOMINI Emanuele
IEZZI Luca
IZZILLO Alessio
MARIOTTI Eleonora
MILANI Stefano
MONTI Flavia
MORVILLO Alberto
ORLANDO Riccardo
PALMA Alessandro
PAPA Lorenzo
ROSSETTI Simone
SABBELLA Sandeep Reddy
SALEM Omar Ashraf Ahmed Khairy
TRAPASSO Alessandro
IZZILLO Alessio

2.5 Visiting Scientists and Scholars

- Manuela VELOSO, February 2024.

2.6 Seminars and Workshops

Many scientists are invited to deliver seminars at DIAG. Below we report the list of seminars for the year 2023, in chronological order. We also report the workshops and special scientific events organized at DIAG.

- January 4, 2024, Eugenio Oropallo: *SEMINARIO PUBBLICO DI EUGENIO OROPALLO (PROCEDURA VALUTATIVA PER N.1 POSTI DI RICERCATORE A TEMPO DETERMINATO TIPOLOGIA A - SC 09/B3 SSD ING-IND/35)*.
- January 15, 2024, Antonio Longa: *Seminar on Graph Neural Networks for temporal graphs: State of the art, open challenges, and opportunities*.
- January 23, 2024, Valerio Schiavoni: *Lessons Learned In Building Trustworthy Systems with Trusted Execution Environments*.
- January 29, 2024, Ricardo Baeza-Yates, Institute for Experiential AI @ Northeastern University: *Responsible AI*.
- January 30, 2024, Giuseppe Antonio Di Luna: *Seminario pubblico Giuseppe Antonio Di Luna*.
- February 2, 2024, Andrea Matta: *Seminar: Towards Autonomous and Adaptable Digital Twins*.
- February 9, 2024, Gustaf Hendeby: *Aspects of Decentralized Tracking under Communication Constraints*.
- February 12, 2024, Gustaf Hendeby: *Wide-Sense Localization Research at Linköping University*.
- February 12, 2024, Alessandro Annarelli: *Seminario pubblico di Alessandro Annarelli*.
- February 19, 2024, Olga Zaghen: *Talk: Nonlinear Sheaf Diffusion in Graph Neural Networks*.
- February 20, 2024, Charles Harris: *Talk: Structure-based Drug Design and Molecular Optimisation with Diffusion Models*.
- February 23, 2024, Professor Manuela M. Veloso: *Symbiotic Human-AI Interaction: Examples in Robotics and Finance*.
- February 29, 2024, Chiara Conti: *Seminario pubblico di Chiara Conti*.
- March 11, 2024, Prof. Stefano Stramigioli (visiting professor, University of Twente): *Portwings: Decoding the physics of flapping flight*.
- March 18, 2024, *Presentazione del libro "Charting Digital Sovereignty: A Survival Playbook" di Roberto Baldoni*.
- April 15, 2024, Lisa Cuneo: *Lisa Cuneo: Explainable-by-design machine learning model for unmixing fluorescence signal based on fluorescence lifetime*.
- April 15, 2024, Gaia Anastasi: *"HE- based Privacy preserving training of ML models through Microsoft SEAL*.

- April 16, 2024, Cinzia Daraio: *Attualità e prospettive del sistema italiano di valutazione della ricerca*.
- April 20, 2024, *Digital Divide - La sfida continua*.
- April 23, 2024, Aristides Gionis, KTH Royal Institute of Technology, Sweden: *Submodular optimization and interpretable machine learning* .
- April 29, 2024, *Conferimento del premio per tesi di laurea magistrale in memoria del prof. Camil Demetrescu*.
- May 9, 2024, Marco Franzoso e Gino Cecchettin: *Violenza di genere: aprire le porte al futuro e alla speranza. La lezione di Giulia Cecchettin.*.
- May 9, 2024, *Seminario percorso di eccellenza - Marco Franzoso - Costruzione di un racconto*.
- May 10, 2024, Prof. Ivan Visconti: *Seminario Pubblico di Ivan Visconti*.
- May 13, 2024, Francesco Liberati:Francesco Liberati: *Optimal Predictive Control of Smart Cyber-physical Systems*.
- May 14, 2024, Francesco Leotta:Francesco Leotta: *Towards Adaptive Context-aware Intelligent Environments*.
- May 16, 2024, Laks V.S. Lakshmanan: *Taming the Cost of Deep Neural Models: Hybrid Models to the Rescue?*.
- May 23, 2024, *Kolmogorov meets Turing - Workshop*.
- May 27, 2024, Daniele Nardi , Marco Schaerf:Benjamin Franchetti, Valerio Giuffrida, Riccardo Denni: *Mini-Workshop on AI approaches to the analysis of plants' health*.
- May 28, 2024, Magdalena Stobinska: *Photonic quantum information processing*.
- May 28, 2024, Cristina Nita-Rotaru: *Leveraging Textual Specifications for Automated Attack Discovery in Network Protocols*.
- June 11, 2024, Stefan Fischer, University of Lübeck, Germany: *DNA-based Nanonetworks: Realizing the Internet of Bio-Nano Things*.
- June 11, 2024, David Bromberg: *Fighting against cyber threats from a system perspective*.
- June 13, 2024, Fabrizio Silvestri:Giulia Di Teodoro, Aleksandra Piktus, Marilena Vendittelli: *Promoting Women's Participation in Data Science*.
- June 20, 2024, *IA e occupazione femminile: opportunità e minacce*.
- June 21, 2024, Prof. Ole-Christoffer Granmo: *Fundamentals of Tsetlin Machines*.
- July 3, 2024, Marco Serafini: *Parallelizing GPU-based Mini-Batch Graph Neural Network Training*.
- July 10, 2024, Prof. Dr. Torsten Braun: *Federated and Split Machine Learning in the Internet of Things*.
- July 11, 2024, *SEMINARIO PUBBLICO DI MARCO ZECCHINI (PROCEDURA VALUTATIVA PER N.1 POSTI DI RICERCATORE A TEMPO DETERMINATO TIPOLOGIA A - SC 09/H1 SSD ING-INF/05)*.
- July 11, 2024, Simone Di Leo: *Seminario Pubblico di Simone Di Leo*.
- July 23, 2024, Romain Malmain, EURECOM: *Finding Bugs in the Large: Towards A Unified Solution for Cross-Architecture Userland and System-Wide Testing*.
- September 19, 2024, Andrea Puligheddu, Riccardo Acciai: *Workshop "Diritto e Nuove Tecnologie"*.

- September 19, 2024, Luca Fraccascia: *Seminario pubblico di Luca Fraccascia*.
- September 30, 2024, *Intelligenza artificiale per inventare il futuro: Luigia Carlucci Aiello pioniera alla Sapienza*.
- October 4, 2024, Marilena Vendittelli: *Transformative Robotic Methodologies in Healthcare*.
- October 7, 2024, Ioannis Chatzigiannakis:Ioannis Chatzigiannakis: *Advancing the Internet of Things: From Sensor Networks towards the full integration in the Cloud Edge Computing Continuum*.
- October 21, 2024, Avigdor Gal: *The Battleship Approach to the Low Resource Entity Matching Problem*.
- October 22, 2024, Fabio Petroni: *Retrieval Augmented Generation (RAG): Applications, Limitations, and Future Directions*.
- October 23, 2024, Pietro Liò: *Actionable and Responsible AI in Medicine*.
- November 11, 2024, Luca Antiga (Lightning AI): *A Journey into PyTorch, the Ecosystem, and Deep Learning Compilers*.
- November 20, 2024, Aldo Razzino - Iacopo Faggiani: *Il Primo Hackathon TELT, un progetto Binazionale ed Europeo, come la tecnologia e i dati possono supportare la costruzione di infrastrutture sostenibili per affrontare le sfide del cambiamento climatico*.
- November 25, 2024, Idiano D'Adamo: *Sustainability: a pragmatic management of resources*.
- November 28, 2024, *IN ASCOLTO contro la violenza sulle donne* .
- December 10, 2024, Lorenzo Marconi: *Seminario pubblico di Lorenzo Marconi*.
- December 13, 2024, Prof. Hyungbo Shim: *Analysis and Synthesis of Emergent Behavior of Multi-agent Systems via Blended Dynamics Theorem*.

2.7 Terza missione

- Gennaio 17, 2024: *Orientamento presso liceo scientifico "Gregorio da Catino"*
- Gennaio 23, 2024 to January 24, 2024: *Orientamento presso il Liceo classico/scienze umane "Benedetto da Norcia"*
- Gennaio 26, 2024: *2 Lezioni di coding per G4Greta*
- Gennaio 31, 2024: *Orientamento presso Liceo Scientifico Sportivo "Convitto Nazionale"*
- Febbraio 8, 2024: *Orientamento presso il Liceo Classico "Ennio Quirino Visconti"*
- Febbraio 11, 2024: *Orientamento presso l'Istituto tecnico per il turismo "Livia Bottardi"*
- Febbraio 18, 2024 al Febbraio 20, 2024: *Orientamento Next Generation - Sapienza - Presso il Liceo Gaetano De Sanctis di Via Antonio Serra*
- Febbraio 21, 2024 to Febbraio 22, 2024: Giorgio Matteucci, Massimo Roma *OpenDIAG Onlife edition 2024*
- Febbraio 22, 2024: *Orientamento presso Liceo socio economico "San Paolo delle Suore Angeliche"*
- Marzo 8, 2024: Tiziana Catarci *Donne, Innovazione, Futuro*
- Marzo 28, 2024: Tiziana Catarci *Rovesciare gli Stereotipi*
- Aprile 10, 2024: Tiziana Catarci *Keynote Convegno Nazionale AIBA*
- Aprile 18, 2024 ad Aprile 19, 2024: Tiziana Catarci *World Forum of Women in Science*
- Aprile 23, 2024: Francesco Costantino *Rischi nuovi ed emergenti per la salute e sicurezza sul lavoro nel contesto di trasformazione digitale*
- Giugno 12, 2024: *Democrazia e Intelligenza Artificiale*
- Luglio 17, 2024 al Luglio 22, 2024: Luca Iocchi, Daniele Nardi *Dai robot calciatori all'intelligenza artificiale*
- Settembre 21, 2024: Tiziana Catarci *Leucemie ph+ Insieme nella Cura*
- Ottobre 19, 2024: Tiziana Catarci *IA a supporto della disabilità*
- Novembre 20, 2024: *Intervento all'evento "Mercoledì 20 novembre, alle 9.00 nella sala delle lauree della Facoltà di Economia, si terrà un incontro dal titolo L'intelligenza artificiale al servizio dell'istruzione e della ricerca. Nuove frontiere e sfide europee"*
- Dicembre 4, 2024 to December 6, 2024: Tiziana Catarci *Rewriters Fest*

2.8 Honours and Awards

- *Inclusion in the "Top 2% Scientists" List (Stanford University & Elsevier, 2024)*, In 2024, Prof. Pietro Aricò was recognized among the world's most influential researchers through inclusion in the prestigious "Top 2% Scientists" list compiled by Stanford University and Elsevier. This international ranking identifies scientists whose research impact places them in the top 2% globally, based on a composite bibliometric indicator that accounts for factors such as total citations, h-index, and authorship position in scientific publications. The

selection is based on data from the Scopus database and includes both career-long impact and performance in the most recent calendar year.
- Laura Astolfi *World's Top 2% Scientists*, https://topresearcherslist.com/Home/Profile/940778
- Francesco Argenziano *Excellent Graduate Sapienza Università di Roma" for the 2021/2022 academic year*, Excellent Graduate Sapienza University of Rome" for the 2021/2022 academic yearAwarded for being in the top 2% (400 out of 19,000) graduates for the 2021/2022 academic year
- Idiano D'Adamo *Top 0.1% Global Scientists Elsevier Stanford University*, Idiano is among Top 0.1% Global Scientists in 2023 provided by Elsevier Stanford University. In particular, the ranking places Idiano in position number 8473, and first two topics of reference are "Energy" and "Environmental Sciences" doi: 10.17632/btchxktzyw.7
- *ACL 2024 Outstanding Paper Award*, ACL 2024 Outstanding Paper Award for the paper "Roberto Navigli, Marco Pinto, Pasquale Silvestri, Dennis Rotondi, Simone Ciciliano, Alessandro Scirè:NounAtlas: Filling the Gap in Nominal Semantic Role Labeling. Proc. of ACL 2024: 16245-16258"
- Roberto Navigli *ELLIS Fellow*, Elected ELLIS Fellow (https://ellis.eu/fellows)
- Ioannis Chatzigiannakis , Stefano Milani *ALGOCLOUD Best Paper Award*
- Ioannis Chatzigiannakis , Stefano Milani *Elsevier Internet of Things Journal Editor's Choice Awards*, Edge2LoRa: Enabling edge computing on long-range wide-area Internet of Things (https://doi.org/10.1016/j.iot.2024.101266)Link Award: https://www.sciencedirect.com/journal/internet-of-things/about/editors-choice#editor-s-choice-awards-july-2024
- Gianluca Cima , Domenico Lembo , Lorenzo Marconi , Riccardo Rosati *Distinguished Paper Award at IJCAI 2024*, L'articolo "Enhancing Controlled Query Evaluation through Epistemic Dependencies" di G. Cima, D. Lembo, L. Marconi, R. Rosati, D.F. Savo, ha vinto il "Distingushed Paper Award" alla conferenza IJCAI 2024 (International Joint Conference on Artificial Intelligence), svoltasi a Jeju, Corea del sud, dal 3 al 9 agosto 2024.
- *ICAPS 2024 Outstanding SPC Award*
- Roberto Navigli *EurAI Fellow*, Elected EurAI Fellow (https://www.eurai.org/award/fellows)

2.9 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.

European Union (EU)
- H2020 - A Collaborative Paradigm for Human Workers and Multi-Robot Teams in Precision Agriculture Systems, € 741.888,75, ending 31-12-2024

- HORIZON-EIC - A Novel EEG Ultrasound Device for Functional Brain Imaging and Neurostimulation, € 341.609,14, ending 28-02-2027
- H2020-ERC - Algorithmic and Mechanism Design Research in Online MArkets, € 1.780.150,00, ending 30-06-2024
- HORIZON-MSCA-2023-PF-01-01 - Algorithmic Auditing for Music Discoverability, € 188.590,00, ending 30-11-2026
- DIGITAL-2021-EDIH-01 - Digital Solutions for a Healthy, Active and Smart Life, € 74.765,95, ending 30-09-2025
- ERASMUS-EDU-2022-PEX-EMJM-MOB - Erasmus Mundus Joint Master In Artificial Intelligence, ending 31-10-2028
- HORIZON-MSCA-2023-SE-01-01 - MSCA Staff Exchanges 2023 - Genomic applications for laboratory Diagnostics supported by Artificial Intelligence, € 138.000,00, ending 31-08-2027
- H2020 - Integrated Infrastructure for Social Mining and Big Data Analytics, € 220.000,00, ending 31-12-2024
- HORIZON-CL4-2023-DATA-01 - Intent-based data operation in the computing continuum, € 200.000,00, ending 31-12-2026
- HORIZON-JU-RIA - Italy for Artificial Intelligence, € 345.000,00, ending 31-03-2028
- HORIZON-INFRA-2021- - SoBigData Research Infrastructure Preparatory Phase Project, € 46.562,50, ending 30-09-2025
- HORIZON-CL4-2023-DIGITAL-EMERGING-01-40 - Soft Optical Aerial Robot Touch - Subgrant Agreement euROBIN project G.A. 101070596, € 60.000,00, ending 30-04-2026
- HORIZON-MSCA-2024-SE-01-01 - Third wave of AI: Neuro-symbolic AI and Large Language Models, € 85.170,00, ending 31-10-2029
- H2020-ICT-2019-3 - Towards a vibrant European network of AI excellence centres, € 308.175,00, ending 31-08-2024
- ERASMUS-LS - Upgrading academic skills and innovative caPacities through virTuAlly Enclusive hybRid Studios, € 71.324,00, ending 31-10-2027
- H2020-ERC - White-Box Self-Programming Mechanisms, € 2.499.197,00, ending 31-10-2024
- Cluster Tecnologico Nazionale Tecnologie per Ambienti di Vita - DANTE: Digital Solutions for a Healthy, Active and Smart Life, Riccardo Lazzeretti , € 5673119,67 , ending 30-04-2026
- Prin 2022 PNRR - P2022NZ8SK - Fit2WORK - Neurophysiological characterization and modelling of “fitness to work”, for enhanced training in virtual reality and safer workplaces, Pietro Arico' , € 239672, ending 30-11-2025
- Horizon Europe - euROBIN Network of Excellence - SOAR-Touch - Soft Optical Aerial Robot Touch, Alessandro De Luca , € 60.000, ending 30-04-2026
- Agence Nationale de la Recherche (ANR) - Telemedicine and precision medicine: The role of data in healthcare innovation, ending 30-06-2025
- Sapienza Università di Roma - WhiteMech: White-box Self-Programming Mechanisms, ERC Advanced Grant, Giuseppe De Giacomo , € 2.499.197, ending 31-10-2024

Istituzioni Italiane

- Ministero Salute - Academic, open label, phase I clinical trial on the use of fresh, allogeneic CD19-CAR T cells for treatment of children with relapsed/refractory B-cell Acute Lymphoblastic Leukemia, € 64.460,00, ending 29-04-2026
- MISE - Scienze della vita - Cloud plAtform for intelligent prevention and Diagnosis sUpported by artifiCial intelligEnce solutiOns , € 698.125,00, ending 31-12-2024
- Ministero Salute - DiSCIoser: Unlocking recovery potential of arm sensorimotor functions after spinal cord injuryby promoting activity-dependent brain plasticity and modeling the causal relationship betweenbrain plasticity and recovery of function, € 90.000,00, ending 31-05-2024
- Ministero Salute - POS - Ecosistema uRbano per l'invecchiaMEnto attivo e in Salute, € 178.450,16, ending 12-02-2027
- INAIL - BRIC 2022 - GURU: Sviluppo di un sistema multisensoriale a realtà mista per l'addestramento dinamico di lavoratori in ambienti ad alto rischio, € 109.945,00, ending 01-05-2025
- Ministero Salute - INTER-RO-GAIT. Patient-therapist INTERaction during RObotic GAIT rehabilitation after Spinal Cord Injury: clinical, instrumental and hyperscanning study , € 80.278,00, ending 31-05-2024
- INAIL - BRIC 2024 - NeuroUX5.0: Design neurergonomico di interfacce uomo-macchina inclusive e adattative nel contesto dell'Industria 5.0, € 244.700,00, ending 30-03-2027
- MISE - Fabbrica intelligente - Sviluppo di una famiglia di elettromandrini innovativi basati sul concetto di Zero Defect Manufacturing, € 448.890,63, ending 31-12-2025
- Ministero della Salute - The PROMOTOER: a Brain Computer Interface-based intervention that promotes upper limb functional motor recovery in subacute stroke patients., Febo Cincotti , € 53889, ending 01-12-2025
- FIS 2 - Discovering critical nodes in Tumor Educated platelets traNscriptome nETwork for cancer diagnosis and monitoring, € 1.324.458,97, ending 31-10-2028

MUR-PRIN

- PRIN 2020 - Acting together: how motor styles shape action prediction and brain-to-brain connectivity in typical and autistic populations, € 281.498,00, ending 31-05-2025
- PRIN 2022 - Artificial Intelligence algorithms to track and detect Covid-19 vaccine-related infodemic on social media., € 97.000,00, ending 28-02-2026
- PRIN 2022 - BIODRONES – Biomimetic and Innovative Optimized hydrodynamic concepts of high-efficiency underwater gliding DRONES for ocean research, € 60.760,00, ending 28-02-2026
- PRIN 2022 - Class-tAIs: Artificial Intelligence and multi-brain connectivity as a buddy to Enhancing Competencies in students, € 61.128,00, ending 28-02-2026

- PRIN 2022 - Conversational Agents: Mastering, Evaluating, Optimizing, € 54.272,00, ending 28-02-2026
- PRIN 2020 - CRoss-modal understanding and gEnerATIon of Visual and tExtual content, € 321.846,00, ending 31-05-2025
- PRIN 2022 - Defining gene regulation and coregulation at single cell resolution in grapevine, € 57.181,00, ending 28-02-2026
- PRIN 2022 - Discount quality for responsible data science: Human-in-the-Loop for quality data, € 48.800,00, ending 28-02-2026
- PRIN 2022 - EdgeVision against Varroa (EV2): Edge computing in defence of bees, € 83.987,00, ending 28-02-2026
- PRIN 2022 - Integrating cutting-edge tools for targeted approach to patients with adrenocortical tumors (COOL-REACT), € 44.400,00, ending 28-02-2026
- PRIN 2022 - ISIDE: Intelligent Systems for Infrastructural Diagnosis in smart-concretE, € 72.232,00, ending 28-02-2026
- PRIN 2022 - Learning in Markets and Society, € 60.977,00, ending 28-02-2026
- PRIN 2022 - Logical methods in combinatorics, € 72.511,00, ending 28-02-2026
- PRIN 2022 - Motown: Smart Production Planning and Control for Manufacturing of Electric Vehicle Powertrain in Industry 4.0 Environment, € 35.776,00, ending 28-02-2026
- PRIN 2022 - NEural REasoning over Open data (NEREO), € 112.160,00, ending 28-02-2026
- PRIN 2022 - POLAR: POLicy specificAtion and enfoRcement for privacy-enhanced data management, € 55.000,00, ending 28-02-2026
- PRIN 2022 - Protecting the Environment: Advances in Circular Economy (PEACE), € 27.830,00, ending 28-02-2026
- PRIN 2020 - Resilient AI-Based Self-Programming and Strategic Reasoning, € 240.000,00, ending 31-05-2025
- PRIN 2022 PNRR - Neurophysiological characterization and modelling of “fitness to work”, for enhanced training in virtual reality and safer, Pietro Arico' , € 151.886,00 , ending 30-11-2025
- MIUR - PRIN 2020 - Resilient AI-Based Self-Programming and Strategic Reasoning (RIPER), Giuseppe De Giacomo , € 275.000, ending 01-06-2025

Regione Lazio

- DTC - Fase 2 - Cicero-Net -- La rete turistica dei luoghi di Cicerone, € 28.565,95, ending 18-01-2024
- FESR Lazio 2021-2027 - RIposizionamento competitivo - Digital Twin City, € 80.942,89, ending 31-12-2025
- FESR Lazio 2021-2027 - RIposizionamento competitivo - Modular Early Threat Identification System, € 144.691,28, ending 31-12-2025
- PROGETTI GRUPPI DI RICERCA 2020-POR FESR Lazio 2014-2020 - Piattaforma Intelligente PEr l’ottimizzazione di operazioni di Riciclo, € 53.937,91, ending 14-04-2024
- DTC - Fase 2 - Sistema Cartografico Informatizzato della Bibliografia Archeologica del Lazio, € 28.100,10, ending 18-01-2024

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
- Engineering in Computer Science
- Economics and 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
- Bioengineering for Molecular Biology and Bioinformatics
- Methods and Techniques for Neuroengineering
- Processing and analysis of bioelectrical signals

Members: ARICO' Pietro, ASTOLFI Laura, CINCOTTI Febo (leader), COLAMARINO Emma, FARINA Lorenzo, FISCON Giulia, PACI Paola, PETTI Manuela and TOPPI Jlenia

Post Docs: DE SETA Valeria, PUXEDDU Maria Grazia, RONCA Vincenzo and SIBILIO Pasquale

PhD students: GERMANO Daniele, MONGIARDINI Elena, QUATTROCIOCCHI Ilaria and RANIERI Andrea

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, biological and biomolecular systems.
Research activities date back to the 70's when novel mathematical models of the human digestive system were proposed. Modelling of physiological systems, including insulin secretion and glucose metabolism, has been the main research activity in the following two decades. Novel methodologies in the analysis of neuroelectrical signals to study the human brain functions have been proposed since the 2000's. Later in the same decade the research interest included the new fields of

computational modeling and analysis of omics data.
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 for precision and network medicine, and by designing innovative instrumentation for neurorehabilitation. The main research topics are:

- Design and validation of EEG-based Brain-Computer Interfaces for assistive and rehabilitation purposes;
- Design and validation of Passive Brain-Computer Interfaces (pBCIs) for mental and emotional states evaluation in operational environments;
- Computational modeling and analysis of omics data for precision and network medicine.
- Estimation of brain connectivity in humans by means of structural and functional models and applications;
- Neuroelectrical hyperscanning and social neuroscience;
- Bioinformatics

Research goals include:

- application of Brain-Computer Interfaces (BCIs) as support to rehabilitation of stroke patients;
- application of passive Brain-Computer Interfaces (pBCIs) in out-of-the-lab applications, especially in operational environments (e.g. aviation, automotive, industrial workers);
- 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.
- use of features extracted from human neuroelectrical activity and connectivity to identify biomarkers of diseases and of physiological mental states
- drug repurposing
- use of bioelectrical signals as biometric features for identification purposes in cybersecurity applications
- identification of disease modules in omics networks

The research group participates in the joint translational research platform established by Sapienza University and IRCCS Fondazione Santa Lucia.

Several other national and international cooperations are actually active, among which: Laboratori di Neuroscienze Industriali - Dip. di Medicina Molecolare, Sapienza Università di Roma; Dip. di Fisiologia Umana e Farmacologia, Sapienza Università di Roma; Dip. di Biotecnologie Cellulari ed Ematologia, Sapienza Università di Roma; Dip. di Medicina sperimentale, laboratorio di Oncogenomica, Sapienza Università di Roma, Laboratorio di Oncogenesi Molecolare, Istituto Nazionale Tumori Regina Elena (Roma); Istituto di Analisi dei Sistemi e Informatica (IASI) – CNR (Roma); Dipartimento di Ingegneria Industriale, Università degli studi di Napoli, Federico II; Laboratorio di Genetica Agraria, Dipartimento di

Biotecnologie, Università di Verona; 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; New Zealand Brain Research Institute, Christchurch, New Zealand, Department of Medicine - Harvard University (USA), Channing division of Network Medicine, Harvard University (USA), Università Campus Bio-Medico di Roma, Martinos Center for Biomedical Imaging - Harvard Medical School, Massachusetts General Hospital.
Facilities available for research and teaching activities include:

- The laboratory of Bioengineering and Bioinformatics (BiBiLab), located in the premises of the Department
- The laboratory of Neuroelectrical Imaging and Brain Computer Interfaces (NEILab), located in the premises of Fondazione Santa Lucia (accessed as part of the joint research platform)

Publications

Journal papers

Ronca Vincenzo, Brambati Francois, Napoletano Linda, Marx Cyril, Trösterer Sandra, Vozzi Alessia, Aricò Pietro, Giorgi Andrea, Capotorto Rossella, Borghini Gianluca, Babiloni Fabio, Di Flumeri Gianluca "A Novel EEG-Based Assessment of Distraction in Simulated Driving under Different Road and Traffic Conditions". In: *Brain Sciences*, (volume: 14) (2024). DOI: 10.3390/brainsci14030193

Colamarino Emma, Morone Giovanni, Toppi Jlenia, Riccio Angela, Cincotti Febo, Mattia Donatella, Pichiorri Floriana "A Scoping Review of Technology-Based Approaches for Upper Limb Motor Rehabilitation after Stroke: Are We Really Targeting Severe Impairment?". In: *Journal Of Clinical Medicine*, (volume: 13) (2024). DOI: 10.3390/jcm13185414

Rossi Dario, Aricò Pietro, Di Flumeri Gianluca, Ronca Vincenzo, Giorgi Andrea, Vozzi Alessia, Capotorto Rossella, Inguscio Bianca M. S., Cartocci Giulia, Babiloni Fabio, Borghini Gianluca "Analysis of Head Micromovements and Body Posture for Vigilance Decrement Assessment". In: *Applied Sciences*, (volume: 14) (2024). DOI: 10.3390/app14051810

De Seta Valeria, Colamarino Emma, Pichiorri Floriana, Savina Giulia, Patarini Francesca, Riccio Angela, Cincotti Febo, Mattia Donatella, Toppi Jlenia "Brain and Muscle derived features to discriminate simple hand motor tasks for a rehabilitative BCI: comparative study on healthy and post-stroke individuals". In: *Journal Of Neural Engineering*, (2024). DOI: 10.1088/1741-2552/ad8838

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Capotorto Rossella, Ronca Vincenzo, Sciaraffa Nicolina, Borghini Gianluca, Di Flumeri Gianluca, Mezzadri Lorenzo, Vozzi Alessia, Giorgi Andrea, Germano Daniele, Babiloni Fabio, Aricò Pietro "Cooperation objective evaluation in aviation: validation and comparison of two novel approaches in simulated environment". In: *Frontiers In Neuroinformatics*, (volume: 18) (2024), pp. 1 - 12. DOI: 10.3389/fninf.2024.1409322

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Toppi J., Quattrociocchi I., Riccio A., Dippolito M., Aloisi M., Colamarino E., Pichiorri F., Cincotti F., Formisano R., Mattia D. "EEG-derived markers to improve prognostic evaluation of Disorders of Consciousness". In: *Ieee Journal Of Biomedical And Health Informatics*, (volume: PP) (2024), pp. 1 - 13. DOI: 10.1109/JBHI.2024.3445118

Filetti Marco, Occhipinti Mario, Cirillo Alessio, Scirocchi Fabio, Ugolini Alessio, Giusti Raffaele, Lombardi Pasquale, Daniele Gennaro, Botticelli Andrea, Lo Russo Giuseppe, De Braud Filippo, Marchetti Paolo, Nuti Marianna, Ferretti Elisabetta, Farina Lorenzo, Rughetti Aurelia, Petti Manuela "Exploring Genomic Biomarkers for Pembrolizumab Response: A Real-World Approach and Patient Similarity Network Analysis Reveal DNA Response and Repair Gene Mutations as a Signature". In: *Cancers*, (volume: 16) (2024). DOI: 10.3390/cancers16233955

Antonacci Yuri, Toppi Jlenia, Pietrabissa Antonio, Anzolin Alessandra, Astolfi Laura "Measuring Connectivity in Linear Multivariate Processes With Penalized Regression Techniques". In: *Ieee Access*, (volume: 12) (2024), pp. 30638 - 30652. DOI: 10.1109/access.2024.3368637

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Patarini F, Tamburella F., Pichiorri F., Mohebban S., Bigioni A., Ranieri A., Di Tommaso F., Tagliamonte N. L., Serratore G., Lorusso M., Ciaramidaro A., Cincotti F., Scivoletto G., Mattia D., Toppi J. "On the role of visual feedback and physiotherapist-patient interaction in robot-assisted gait training: an eye-tracking and HD-EEG study". In: *Journal Of Neuroengineering And Rehabilitation*, (2024).

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Borghini Gianluca, Ronca Vincenzo, Giorgi Andrea, Aricò Pietro, Di Flumeri Gianluca, Capotorto Rossella, Rooseleer Frédéric, Kirwan Barry, De Visscher Ivan, Goman Mikhail, Pugh Jonathan, Abramov Nikolay, Granger Géraud, Alarcon Diana Paola Moreno, Humm Elizabeth, Pozzi Simone, Babiloni Fabio "Reducing flight upset risk and startle response: A study of the wake vortex alert with licensed commercial pilots". In: *Brain Research Bulletin*, (volume: 215) (2024), pp. 1 - 17. DOI: 10.1016/j.brainresbull.2024.111020

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3.2 Engineering in Computer Science

3.2.1 Algorithms and Data Science

Research lines:

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

Members: ANAGNOSTOPOULOS Aris, BECCHETTI Luca, BRUSTLE Johannes, FUSCO Federico, LEONARDI Stefano (leader), SICILIANO Federico, SILVESTRI Fabrizio, TRAPPOLINI Giovanni (Former), FAZZONE Adriano (Former) and MARCHETTI-SPACCAMELA Alberto (Former)

Post Docs: BARNABÒ Giorgio (Former), BUCARELLI Maria Sofia, FIORAVANTI Simone, BIRMPAS Georgios (Former), EZRA Tomer (Former), LAZOS Philip (Former) and REIFFENHAUSER Rebecca (Former)

PhD students: DI GREGORIO Simone, GENTILI Michele (Former), MARTINI Leonardo (Former), MASTROPIETRO Andrea (Former), PAWLOWSKI Michal and RUSSO Matteo

The focus of the Algorithms and Data Science group is on theoretical and applied research in the areas of algorithms and data science. The main focus in on 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.
The group is particularly active in the following areas:

- Algorithmic Fairness
- Algorithmic Game Theory and Mechanisms Design
- Approximation and Online Algorithms
- Distributed and Streaming Computation
- Internet Economics
- Large-Scale Data Mining

- Online Learning
- Social Network Analysis
- Submodular Optimization
- Theory and Applications of Machine Learning.

Publications

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Feldman Michal, Fusco Federico, Leonardi Stefano, Mauras Simon, Reiffenhäuser Rebecca "Truthful Matching with Online Items and Offline Agents". In: Algorithmica, (2024). DOI: 10.1007/s00453-023-01202-3

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Bernasconi M., Castiglioni M., Celli A., Fusco F. "No-Regret Learning in Bilateral Trade via Global Budget Balance". In: Stoc 2024: Proceedings Of The 56th Annual Acm Symposium On Theory Of Computing, (2024), pp. 247 - 258. DOI: 10.1145/3618260.3649653

Berger Ben, Ezra Tomer., Feldman Michal, Fusco Federico "Pandora's Problem with Deadlines". In: Proceedings Of The 38th Aaai Conference On Artificial Intelligence, (volume: 38) (2024), pp. 20337 - 20343. DOI: 10.1609/aaai.v38i18.30015

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Becchetti Luca, Clementi Andrea, Pasquale Francesco, Trevisan Luca, Vacus Robin, Ziccardi Isabella "The Minority Dynamics and the Power of Synchronicity". In: Proceedings Of The 2024 Annual Acm-siam Symposium On Discrete Algorithms, (2024), pp. 4155 - 4176. DOI: 10.1137/1.9781611977912.144

Cesa-bianchi N., Cesari T., Colomboni R., Fusco F., Leonardi S. "The Role of Transparency in Repeated First-Price Auctions with Unknown Valuations". In: Stoc 2024: Proceedings Of The 56th Annual Acm Symposium On Theory Of Computing, (2024), pp. 225 - 236. DOI: 10.1145/3618260.3649658

3.2.2 Artificial Intelligence and Knowledge Representation

Research lines:

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

Members: CIMA Gianluca, CONSOLE Marco, DE GIACOMO Giuseppe, LEMBO Domenico, LENZERINI Maurizio, LIBERATORE Paolo, NARDI Daniele, NAVIGLI Roberto, PATRIZI Fabio, POGGI Antonella, ROSATI Riccardo (leader), SCAFOGLIERI Federico Maria and UMILI Elena

PhD students: ANDOLFI Luca, BRUNORI Damiano, CHIARIELLO Francesco, CIPOLLONE Roberto, DELFINO Roberto Maria, MARCONI Lorenzo, NAMICI Manuel, PALUDO LICKS Gabriel, PAPI Laura, PARRETTI Gianmarco, SILO Luciana, TRAPASSO Alessandro and VALENTINI Riccardo

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 the theory of actions; various forms of planning or automated process synthesis for sophisticated dynamic properties, e.g., expressed in mu-calculus, ATL, LTL, LTLf, and LDLf; 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.

The group is also focusing on Reinforcement Learning in the presence of non-Markovian Rewards, as well as on using logic-based abstraction and prior knowledge to improve the performance of the learning process.

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.

Finally, the group also investigates the synergistic integration of Natural Language Processing and Knowledge Representation.

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.

Publications

Journal papers

Cima Gianluca, Lembo Domenico, Marconi Lorenzo, Rosati Riccardo, Savo Domenico

Fabio "A Gentle Introduction to Controlled Query Evaluation in DL-Lite Ontologies". In: Sn Computer Science, (volume: 5) (2024). DOI: 10.1007/s42979-024-02652-4

Conference proceedings

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Andolfi Luca, Cima Gianluca, Console Marco, Lenzerini Maurizio "What Does a Query Answer Tell You? Informativeness of Query Answers for Knowledge Bases". In: Proceedings Of The Aaai Conference On Artificial Intelligence, (volume: 38) (2024), pp. 10442 - 10449. DOI: 10.1609/aaai.v38i9.28912

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3.2.3 Artificial Intelligence and Robotics

Research lines:

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

Members: BERNARDINI Sara, CIARFUGLIA Thomas Alessandro, GRISETTI Giorgio, IOCCHI Luca, NAPOLI Christian, NARDI Daniele (leader) and UMILI Elena

Post Docs: DI GIAMMARINO Luca, SOROKOLETOVA Olga, BRIGATO Lorenzo (Former), CARBONE LORIO Carlos Salvador (Former), RICCIO Francesco (Former) and WANG Lun (Former)

PhD students: ANTONIONI Emanuele (Former), ARGENZIANO Francesco, BAZZANA Barbara, BRANDIZZI Nicolo', BRIENZA Michele , BRIZI Leonardo (Former), BRUNORI Damiano, CATACORA OCANA Jim Martin, CERIOLA Davide, DE MAGISTRIS Giorgio, DE REBOTTI Lorenzo, DI VALERIO Federico, FANTI Andrea, FAWAKHERJI Mulham (Former), FEOLA Luigi (Former), FERRARI Simone, FRATTOLILLO Francesco, GALLETTI Martina, IACOBELLI Emanuele, KASZUBA Sara (Former), LA ROSA Biagio (Former), MOTOI Ionut Marian, MUSUMECI Emanuele, PONZI Valerio, PROIETTI Michela, PUGLISI Adriano, RAGNO Alessio (Former), SABBELLA Sandeep Reddy (Former), SALADINO Alessio (Former), SALEM Omar Ashraf Ahmed Khairy (Former), SARACENI Leonardo, SCHLEGEL Dominik (Former), SURIANI Vincenzo (Former), TIBERMACINE Imad Eddine, TRAPASSO Alessandro and YOUSSEF ALI (Former)

Affiliated: Capobianco Roberto

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 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 and semantic representations of the environment. 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 leverages its extensive experience gained from participating in robot competitions such as RoboCup, which began in 1998. These competitions span various domains, including robot soccer, where the lab actively engages with the SPQR Team in the Standard Platform League using humanoid robots, as well as competitions focused on Rescue, @Home, and @Work scenarios. 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, precision 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 on our Web site www.diag.uniroma1.it/˜labrococo. They include the design of educational mobile robots and many software libraries for AI and Robotics application development.

Publications

Journal papers

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Rossi Alessandra, Paetzel-prüsmann Maike, Keijsers Merel, Anderson Michael, Anderson Susan Leigh, Barry Daniel, Gutsche Jan, Hart Justin, Iocchi Luca,

Kokkelmans Ainse, Kuijpers Wouter, Liu Yun, Polani Daniel, Roscon Caleb, Scheunemann Marcus, Stone Peter, Vahl Florian, Van De Molengraft René, Von Stryk Oskar "The human in the loop Perspectives and challenges for RoboCup 2050". In: Autonomous Robots, (volume: 48) (2024). DOI: 10.1007/s10514-024-10159-3

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Galletti Martina, Pasqua Eleonora, Calanca Manuela, Marchesi Caterina, Tomaiuoli Donatella, Nardi Daniele "ARTIS: a digital interface to promote the rehabiliatation of text comprehension difficulties through Artificial Intelligence". In: Ital-ia 2024: 4th National Conference On Artificial Intelligence, Organized By Cini, May 29-30, 2024, Naples, Italy, (2024).

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3.2.4 Computer Networks and Pervasive Systems

Research lines:

- Augmented Reality
- Blockchain Technologies
- Decentralized Applications
- Fog Computing
- Internet of Things
- Networks of Resource Constrained Devices
- Parallel and Distributed Computing Platforms
- Self-* Protocols and Systems
- Wireless and Sensor Networks

Members: BECCHETTI Luca, BERALDI Roberto, CHATZIGIANNAKIS Ioannis (leader), PROIETTI MATTIA Gabriele, QUERZONI Leonardo, VITALETTI Andrea and MARCHETTI-SPACCAMELA Alberto

PhD students: JIMENEZ GUTIERREZ Daniel Mauricio and MILANI Stefano

The group is conducting research on emerging networking technologies and modern pervasive systems. Our research in these areas involves both theoretical investigations and practical implementations. We work closely with industry partners to design and deploy real-world networking solutions that leverage these emerging technologies. The research activity is supported by the Wireless Sensor Networks Laboratory.
Theories, models, and algorithms: Models for dynamic networks; hierarchical and heterogeneous networks; fast-evolving networks; network dynamics; network growth and evolution; epidemic processes; population protocols; complex networks; scale-free algorithms; local algorithms; applied machine learning; federated learning.
Domain-specific challenges and novel applications: urban/mobile crowdsensing & intelligence; pervasive systems for healthcare and well-being; smart water metering services; cyber-physical pervasive systems; smart homes and virtual assistants; mixed reality; pervasive AR/VR; smart vehicles; disaster sensing and management.
Technological innovations: architectures, protocols, and technologies for pervasive communications; stream processing; cloud-edge processing continuum; resource allocation in fog computing; energy-harvesting, energy-transfer, self-powered, or battery-less systems; mobile and wearable systems; smart devices and environments; positioning, navigation, timing, and tracking technologies; device-free human sensing; blockchains and smart contracts.

Publications

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3.2.5 Computer Vision, Computer Graphics, Deep Learning

Research lines:

- Action and Activity Recognition
- Activity Understanding from 3D data
- Anticipation and Forecasting
- Augmented Reality
- Forensics
- Gesture Recognition
- Human Motion Analysis
- Machine learning and AI security
- Memory and next step prediction in Long Short Time Memory (LSTM) Networks
- Physics based methods
- Scene Representation
- Visual Search and Execution Monitoring

Members: AMERINI Irene, BERALDI Roberto, PROIETTI MATTIA Gabriele, RUSSO Paolo and SCHAERF Marco (leader)

Post Docs: BAZZANA Davide and MAIANO Luca

PhD students: CIRILLO Lorenzo, GIOVANNESI Luca, MAJID Taiba, MANGANELLI CONFORTI Pietro, MAURO Lorenzo, MELIS TONTI Claudia, PAPA Lorenzo, PRO Francesco, SCHIAVELLA Claudio and TEGLIA Simone

Affiliated: PIRRI Fiora (Former)

The Computer Vision, Computer Graphics, Deep Learning group is a multidisciplinary team of researchers that investigates several knowledge areas in vision and apply them to scientific problems in many contexts.
The team works on several topics related to Computer Vision, Pattern Recognition, Deep Learning, Multimedia applied to optical images and videos as well as data from different sensors and Computer Graphics.
Some of the topics covered are the following: Edge-Vision and Efficient deep learning, Multimedia Forensics and Deepfake detection, Deep Learning for image and video analysis, Visual Knowledge acquisition: Activity Recognition & Object Detection, Computer Graphics and Point cloud representation, Monocular Depth Estimation, Energy aware deep learning models and Green AI (Beekeeping and Vertical farming), Adversarial Machine Learning.
Visit the website ALCORLab
Lightweight DL models for resource constraints device — Investigating both mathematically and practically, research areas related to the efficiency of DL models for computer vision tasks. More in detail, the objective is to theoretically

analyze and investigate the behavior of fundamental components for neural network learning mechanisms, with a focus on specific layers and elements that characterize the learning procedure, such as self-attention, knowledge distillation, and optimizers. More in detail, computationally efficient solutions are developed in the fields of perception and security, i.e., studying efficient techniques in well-known tasks like monocular depth estimation, 3D mesh reconstruction, and deepfake detection. Additionally, the key elements of neural network efficiency is analyzed, such as inference time, energy consumption, and their trade-off with estimation performances.

Multimedia forensics and deepfake detection — Multimedia Forensics includes a set of scientific techniques recently proposed for the analysis of multimedia signals (audio, videos, images) in order to recover probative evidences from them; in particular, such technologies aim to reveal the history of digital contents, such as identifying the acquisition device that produced the data, validating the integrity of the contents and retrieving information from multimedia signals. With our research, we seek to study these models to create defense solutions against disinformation attacks based on diffusion models and generative techniques..

Action and Activity Recognition, Anticipation and Forecasting — Different works in literature afford the problem of Actions and Activities Recognition, Anticipation and Prediction in videos. The complexity of the problem requires the consideration of many aspect. First of all, the recognized action sequence has to be consistent with the final task of the whole activity. Furthermore, much attention needs to be given to the prediction of the correct action in those instances where specific sequences are under represent in the dataset not because of the likelihood of them to happen. Finally, several implementation problems, caused by the large dimension of the data used, need to be addressed. Our researched work focused on tackling those problems producing a novel network, the Anticipation and Forcasting Network.

Object Detection and Instance Segmentation — Object detection is the task of detecting instances of certain object classes (such as humans, buildings or cars) in digital images and videos. Well-researched sub-tasks include face detection and pedestrian detection. Instance segmentation is the task of grouping parts of the image that belongs to the same entity or class. In the field of research that combines Object Detection and Instance Segmentation, a new approach is proposed: from the classical machine learning algorithms, the research community moved to a neu ral network approach via the use of several new architecture. Our research focused on developing new architectures by improving performances, computation time, capacity and multi-tasking properties.

Edge and Fog Computing — Distributed algorithms are stutied, resource-sharing strategies, and scheduling policies that best fit this new kind of computing paradigm. We have expertise in the mathematical modeling of the problem, simulation tools and in modern technologies like Docker and Kubernetes.

Impact of adversarial and backdoor attacks on deep learning techniques — In the last couple of decades, machine learning and neural networks applications have quickly become the state of the art in every automated task. Moreover, the

spreading of high-performance GPUs at an affordable price, along with the creation of frameworks that are always simpler to use, have made the implementation of neural network architectures accessible to everyone. Nevertheless these techniques have been found to be highly exposed to malicious approaches. Malicious approaches usually refer to an adversarial scenario, in which an attacker tries to exploit vulnerabilities of a system in order to gain advantages from it.

Publications

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3.2.6 Cybersecurity

Research lines:

- Application security
- Blockchain Technologies
- Blockchains and distributed ledger security
- Cloud security
- Cyber physical systems security
- Data privacy and security
- Distributed systems security
- Economics of security and privacy
- Embedded systems security
- Hardware security
- Machine learning and AI security
- Malware Analysis
- Mobile security
- Network and systems security
- Protocol security
- Robot Security
- Secure and robust distributed systems
- Security and privacy for the Internet of Things
- Security and privacy metrics
- Security architectures
- Security awareness
- Security for cyber-physical systems
- Security governance
- Threat intelligence
- Usable security and privacy

- Web security

Members: AMERINI Irene, BERALDI Roberto, BONOMI Silvia, CATARCI Tiziana, D'AMORE Fabrizio, D'ELIA Daniele Cono, DELLI PRISCOLI Francesco, DI GIORGIO Alessandro, DI LUNA Giuseppe Antonio, IOCCHI Luca, LAZZERETTI Riccardo, LEMBO Domenico, PIETRABISSA Antonio, QUERZONI Leonardo (leader), ROSATI Riccardo, SANTUCCI Giuseppe, VISCONTI Ivan, ANGELINI Marco (Former), COPPA Emilio (Former), DEMETRESCU Camil (Former) and MARCHETTI-SPACCAMELA Alberto

Post Docs: TORTORELLI Andrea, BORZACCHIELLO Luca (Former) and BRIGATO Lorenzo (Former)

PhD students: ARTUSO Fiorella (Former), ASSAIANTE Cristian, BARDHI Enkeleda (Former), BORRELLO Pietro (Former), BOTTURA Nicola, CAPOZZI Gianluca, CARELLO Maria Patrizia (Former), CONSOLE Francesca (Former), CUOCI Marco, DI PIETRO Giorgia, FERRACCI Serena (Former), IZZILLO Alessio, MARINI Matteo, PALMA Alessandro and PRIAMO Giacomo

The cybersecurity group is a multidisciplinary team tackling scientific problems in IT security. Research spans multiple domains:
Analysis-Resistant Code. Developing methods for analyzing adversarial code, protecting software from reverse engineering, and studying evasive malware with dynamic instrumentation and weird-machine abstractions.
Attack Modeling. Improving attack graph scalability and enriching them with information beyond network vulnerabilities, including application and human factors.
Binary Code Representation. Automated techniques using deep neural networks for large-scale binary analysis, covering binary similarity and automated function naming, developed in collaboration with industry and universities.
Blockchain. Studying blockchain performance and security, addressing scalability and resilience against attacks in decentralized systems.
Code Reuse Attacks and Defenses. Investigating ROP attacks, building exploit datasets, developing analysis tools, and optimizing defenses using modern processor primitives.
Cryptography for E-Government. Building cryptographic protocols for major e-government services such as e-voting, contact tracing, and digital identity wallets.
Cyber-Physical Systems. Protecting SCADA-controlled infrastructures and robots through control-theoretical and machine learning approaches, using anomaly detection and behavioral analysis to enhance resilience and safety.

Foundations of Cryptography. Identifying lower and upper bounds on the number of communication rounds, amount of communication, hardness assumptions, computational complexity, and setup assumptions required by algorithms realizing cryptographic tasks.
Malware Analysis Tools. Semi-automatic triage systems prioritize malware samples for human analysis, reducing computational and analyst overload.
Multimedia Forensics. Methods for verifying image/video authenticity, detecting forgeries and deepfakes, and tracing digital content origins for investigations and information warfare.
Post-Quantum Cryptography. Upgrading existing cryptographic infrastructures to maintain the desired level of security even against quantum adversaries.
Privacy-Enhancing Cryptography. Improving privacy-preserving cryptographic schemes (e.g., blind signatures, ring signatures, zero-knowledge proofs, secure multi-party computation) to guarantee user privacy while enabling computation over confidential data.
Privacy-Preserving Applications. Encrypted computation for secure biometric matching, biomedical signals, IoT sensor fusion, and private malware analysis.
Side Channels. Researching software hardening and hardware vulnerabilities to protect sensitive data from microarchitectural attacks.
Swarm Attestation. Improving IoT device attestation performance using noninteractive collective protocols suitable for low-end devices and unstructured networks.
Symbolic Execution. Advancing symbolic execution for vulnerability detection, protocol reconstruction, and hybrid fuzzing, with applications in malware analysis and program verification.
Visual Analytics. Interactive tools to analyze large cybersecurity datasets, support proactive risk assessment, real-time incident response, and explain AI-driven malware classifiers.
Group members also contribute to the **Research Center for Cyber Intelligence and Information Security (CIS)**, conducting applied research in cyber intelligence, critical infrastructure protection, trend prediction, and threat mitigation. CIS develops strategies and tools for real-world challenges such as cyberwarfare, fraud detection, stock market stability, tax evasion, mission-critical monitoring, early warning systems, and smart environments.

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3.2.7 Data Management and Semantic Technologies

Research lines:

- Data cleaning
- Data Integration and Exchange
- Data quality
- Data Warehousing
- Ontology Based Data Management

- Process and Workflow Management
- Service Modeling
- Service Synthesis and Composition

Members: CATARCI Tiziana, CIMA Gianluca, CONSOLE Marco, DE GIACOMO Giuseppe, LEMBO Domenico, LENZERINI Maurizio (leader), LEOTTA Francesco, MECELLA Massimo, PATRIZI Fabio, POGGI Antonella, ROSATI Riccardo and SCAFOGLIERI Federico Maria

Post Docs: CROCE Federico

PhD students: ANDOLFI Luca, DELFINO Roberto Maria, MARCONI Lorenzo, NAMICI Manuel and VALENTINI Riccardo

Our interest in Data Management dates back to the 80's, when the main research topics addressed by our group were conceptual modeling and schema integration. Starting in the late 90's, it 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 ap- plications. 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:

posing the semantics of the application domain at the center of the scene,
combining the management of data with the management of the processes and services using such data in the organization, and
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 2022, members of the research group have been invited to organize various events, and to deliver keynote speeches at various conferences and workshops.

Publications

Journal papers

Cima Gianluca, Lembo Domenico, Marconi Lorenzo, Rosati Riccardo, Savo Domenico Fabio "A Gentle Introduction to Controlled Query Evaluation in DL-Lite Ontologies". In: Sn Computer Science, (volume: 5) (2024). DOI: 10.1007/s42979-024-02652-4

Conference proceedings

Cima Gianluca, Lembo Domenico, Marconi Lorenzo, Rosati Riccardo, Savo Domenico Fabio "Enhancing Controlled Query Evaluation through Epistemic Policies". In: Proceedings Of The Thirty-third International Joint Conference On Artificial Intelligence (ijcai-24), (2024), pp. 3307 - 3314. DOI: 10.24963/ijcai.2024/366

Andolfi Luca, Cima Gianluca, Console Marco, Lenzerini Maurizio "What Does a Query Answer Tell You? Informativeness of Query Answers for Knowledge Bases". In:

Proceedings Of The Aaai Conference On Artificial Intelligence, (volume: 38) (2024), pp. 10442 - 10449. DOI: 10.1609/aaai.v38i9.28912

Cima Gianluca, Lembo Domenico, Marconi Lorenzo, Rosati Riccardo, Savo Domenico Fabio "Controlled Query Evaluation in DL-Lite through Epistemic Protection Policies (Extended Abstract)". In: Proceedings Of The 37th International Workshop On Description Logics (dl 2024), (volume: 3739) (2024).

3.2.8 Distributed Systems

Research lines:

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

Members: BERALDI Roberto, BONOMI Silvia (leader), DI LUNA Giuseppe Antonio, PROIETTI MATTIA Gabriele, QUERZONI Leonardo and FARINA Giovanni

Affiliated: BALDONI Roberto *(Former)* and CICIANI Bruno *(Former)*

PhD students: PALMA Alessandro and SCANU Fabio

The Distributed Systems group has developed, in the last fifteen 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. We developed several theories and practical experiences in various topics including checkpointing, causal and total ordering theory, distributed replication, group communication, distributed agreement, publish subscribe systems, dynamic systems, byzantine fault tolerance, distributed stream processing, etc.

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 critical infrastructures. 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.

Current research areas include:

Byzantine fault-tolerant algorithms: in the past few years the group has proposed several solutions in the area of BFT focussing, in particular, on algorithms for basic distributed abstractions in both static and dynamic settings and algorithms for robust

lattice agreement algorithms. In this context, the group is also investigating solutions able to deal with the so called Mobile Byzantine Failure model.

Distributed stream processing systems: since 2003 the group has regularly proposed novel solutions for improving the efficiency of distributed stream processing systems. In particular, we focussed our efforts on designing solutions to dynamically adapt the system runtime to changes in the input load distribution to tackle different goals (e.g. latency reduction, throughout maximization, efficient resource usage, etc.)

Dynamic networks and population protocols: The group has a keen interest in the study of dynamic networks, especially the one composed by anonymous processes. In this area, it has designed the first known terminating counting algorithms for rooted interval-connected networks, bootstrapping the research in the field. Regarding, population protocols the group has been the first to investigate computability under faulty interactions increasing the understanding of fault-tolerance for population protocols. The group also provided contribution to the analysis of theoretical aspect of distributed systems affected by continuous churn i.e., the phenomenon of continuously changing the set of processes participating in to the distributed system.

Mobile agents and robots: The DS group has strong expertise in the field of mobile agents (autonomous entities inhabiting a graph) and mobile robots (autonomous entities inhabiting an euclidean space). Regarding mobile agents, it has been the first to investigate, with a distributed perspective, the problems of exploration, gathering, patrolling, and black hole search on dynamic interval connected graphs. While in the field of robots it has been the first to study the computational power of luminous robots in the obstructive model, and it has given general contributions in understanding the computational power of oblivious robots in the setting of restricted visibility.

DLT and Blockchain: in the fast few years the group started to investigate the theoretical foundations of Blockchains and (more in general) of DLT and how to efficiently take advantage of such technologies to support applications behind cryptocurrencies.

Fog and Edge Computing: The DS group also has experience in designing distributed, cooperative, and decentralized algorithms that target the problems of load balancing and scheduling problems in the Edge and Fog Computing environments. With the former, we intend to optimize the load among all the nodes involved in the system to avoid saturation and consequently increase the number of successfully served tasks and minimize the latency, while in the latter, we deal with tasks that have specific deadlines that they necessarily need to meet. We have expertise in mathematical modeling (probabilistic models, linear optimization, and discrete/continuous time systems) of the problem and modern technologies like Docker and Kubernetes. Moreover, we also rely on Reinforcement Learning to design adaptive and resilient strategies that cope with unpredictable changes in the environment in which the algorithm runs. In general, our main objective is to start from the problem analysis, then model the system and the solution, and finally implement a working approach both in simulation and on real and pseudo-real environments, such as clusters of Raspberry Pis. For this reason, the group also developed an open-source framework called P2PFaaS (https://p2p-faas.gitlab.io) which allows the implementation of

cooperative and decentralized scheduling and load-balancing algorithms on Fog and Edge nodes which are Docker-enabled.
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.

Publications

Journal papers

Bonomi Silvia, Farina Giovanni, Tixeuil Sébastien "Reliable Communication in Dynamic Networks with Locally Bounded Byzantine Faults". In: Journal Of Parallel And Distributed Computing, (2024). DOI: 10.1016/j.jpdc.2024.104952

Conference proceedings

Di Luna Giuseppe A., Viglietta Giovanni "Efficient Computation in Congested Anonymous Dynamic Networks". In: *49th International Symposium On Mathematical Foundations Of Computer Science (mfcs 2024)*, (2024).

Bonomi Silvia, Farina Giovanni, Tixeuil Sébastien "Reliable Broadcast Despite Mobile Byzantine Faults". In: *27th International Conference On Principles Of Distributed Systems (opodis 2023)*, (2024). DOI: 10.4230/lipics.opodis.2023.18

Scanu Fabio, Farina Giovanni, Bonomi Silvia "SoK on DLT Solutions for Agri-food Traceability". In: *2024 6th International Conference On Blockchain Computing And Applications (bcca)*, (2024), pp. 642 - 647. DOI: 10.1109/BCCA62388.2024

3.2.9 Human-Computer Interaction

Research lines:

- Automated Personalization and Adaptation in Web-based Learning
- Game-based Technology-Enhanced Learning
- Information Visualization
- Usability Engineering and Accessibility

- User Interfaces
- Visual control
- Web-based Social Collaborative Learning

Members: AGOSTINELLI Simone, BLASILLI Graziano, CATARCI Tiziana (leader), LENTI Simone, LEOTTA Francesco, MARRELLA Andrea, MECELLA Massimo, SANTUCCI Giuseppe, TEMPERINI Marco and ANGELINI Marco

Post Docs: MONTI Flavia and SAPIO Francesco

PhD students: ACITELLI Giacomo, BENVENUTI Dario, DE LUZI Francesca, FERRO Lauren, MACRI Mattia, MATHEW Jerin George, MORVILLO Alberto, PALLESCHI Alessia and VENERUSO Silvestro V.

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, re- ferring 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 formaliza- tion 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 in- formation 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 dif- ferent 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 develop- ment, 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 inter- national 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 Dis- tance 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 is member of the Steering Committee of the Synposium IEEE VizSec (Symposium on Visualization for Cybersecurity) https://vizsec.org/.
- Marco Angelini is the Program co-chair of the 14th EuroVis Workshop on Visual Analytics (EuroVA) 2023 https://www.eurova.org/eurova-2023.
- Marco Angelini is member of the Program Committee for the short-paper track of EuroVis 2023 https://www.eurovis.org/.
- Marco Angelini has been co-chair of ITA.WA, 1st Italian workshop on Advanced Visualizations and Visual Analytics, co-located at AVI 2018.

Publications

Journal papers

Porcaro Lorenzo, G('(o))mez Emilia, Castillo Carlos "Assessing the Impact of Music Recommendation Diversity on Listeners: A Longitudinal Study". In: Acm Transactions On Recommender Systems, (volume: 2) (2024). DOI: 10.1145/3608487

Hupont Isabelle, Tolan Songül, Frau Pedro, Porcaro Lorenzo, Gómez Emilia "Measuring and Fostering Diversity in Affective Computing Research". In: Ieee Transactions On Affective Computing, (volume: 15) (2024), pp. 63 - 78. DOI: 10.1109/TAFFC.2023.3244041

Sala Arianna, Porcaro Lorenzo, Gómez Emilia "Social Media Use and adolescents' mental health and well-being: An umbrella review". In: Computers In Human Behavior Reports, (volume: 14) (2024). DOI: 10.1016/j.chbr.2024.100404

Conference proceedings

Porcaro L., Gomez E., Catarci T. "End-user Algorithmic Auditing for Music Discoverability: A Research Roadmap". In: Murs 2024 Murs: 2nd Music Recommender Systems Workshop 2024, (volume: 3787) (2024), pp. - 6.

Ferraro Andres, Porcaro Lorenzo, Knees Peter, Bauer Christine "MuRS 2024: 2nd Music Recommender Systems Workshop". In: Recsys '24: Proceedings Of The 18th Acm Conference On Recommender Systems, (2024), pp. 1202 - 1205. DOI: 10.1145/3640457.3687097

3.2.10 Natural language processing

Research lines:

- Multilinguality
- Natural Language Processing
- Natural Language Understanding

Members: BARBA Edoardo, CONIA Simone and NAVIGLI Roberto (leader)

PhD students: BEJGU Andrei Stefan, BONOMO Tommaso, HUGUET CABOT Pere-Lluis, MARTINELLI Giuliano, MOLFESE Francesco Maria, ORLANDO Riccardo, PERRELLA Stefano and PROIETTI Lorenzo

The Sapienza Natural Language Processing Group (Sapienza NLP), led by prof. Roberto Navigli, includes a large team of Ph.D. students and researchers which are part of the Computer, Control and Management Engineering Department and the Computer Science Department of the Sapienza University of Rome. The group aims at devising and developing innovative approaches to multilingual Natural Language Understanding and Generation. Sapienza NLP pursues a vision focused on integrating explicit, symbolic information with cutting-edge deep learning. The group's work is financed by several sources of funding, including ERC grants, other EU and national projects, and the Babelscape, a successful spin-off company.

Publications

Conference proceedings

Proietti Lorenzo, Perrella Stefano, Tedeschi Simone, Vulpis Giulia, Lavalle Leonardo, Sanchietti Andrea, Ferrari Andrea, Navigli Roberto "Analyzing Homonymy Disambiguation Capabilities of Pretrained Language Models". In: Proceedings Of The 2024 Joint International Conference On Computational Linguistics, Language Resources And Evaluation (lrec-coling 2024), (2024), pp. 924 - 938.

Molfese Francesco Maria, Bejgu Andrei Stefan, Tedeschi Simone, Conia Simone, Navigli Roberto "CroCoAlign: A Cross-Lingual, Context-Aware and Fully-Neural Sentence Alignment System for Long Texts". In: Proceedings Of The 18th Conference Of The European Chapter Of The Association For Computational Linguistics (volume 1: Long Papers), (volume: 1) (2024), pp. 2209 - 2220.

3.2.11 Processes, Services and Software Engineering

Research lines:

- Internet of Things
- Process and Workflow Management
- Reasoning about Actions and Planning

- Service Synthesis and Composition

Members: AGOSTINELLI Simone, LEOTTA Francesco, MARRELLA Andrea (leader) and MECELLA Massimo (leader)

PhD students: ACITELLI Giacomo, BENVENUTI Dario, DE LUZI Francesca, MACRI Mattia, MARINACCI Matteo, MATHEW Jerin George and VENERUSO Silvestro V.

Post Docs: MONTI Flavia

Gruppo di ricerca Processes, Services and Software Engineering

Publications

Journal papers

Palma Alessandro, Acitelli Giacomo, Marrella Andrea, Bonomi Silvia, Angelini Marco "A compliance assessment system for Incident Management process". In: Computers & Security, (volume: 146) (2024). DOI: 10.1016/j.cose.2024.104070

Luca Bernardi Mario, Casciani Angelo, Cimitile Marta, Marrella Andrea "Conversing with business process-aware large language models: the BPLLM framework". In: Journal Of Intelligent Information Systems, (2024), pp. 1 - 23. DOI: 10.1007/s10844-024-00898-1

De Luzi Francesca, Leotta Francesco, Marrella Andrea, Mecella Massimo "On the Interplay Between Business Process Management and Internet-of-Things". In: Business & Information Systems Engineering, (2024), pp. 1 - 24. DOI: 10.1007/s12599-024-00859-6

Bianchini Filippo, Calamo Marco, De Luzi Francesca, Macrì Mattia, Mecella Massimo "Enhancing Complex Linguistic Tasks Resolution Through Fine-Tuning LLMs, RAG and Knowledge Graphs (Short Paper)". In: International Conference On Advanced Information Systems Engineering, (2024), pp. 147 - 155. DOI: 10.1007/978-3-031-61003-5_13

Marrella A., Resinas M., Jans M., Rosemann M. "Preface of 22nd International Conference on Business Process Management, BPM 2024". In: , (2024), pp. v - vii.

Conference proceedings

Agostinelli S., Benvenuti D., Casciani A., De Luzi F., Marinacci M., Marrella A., Rossi J. "A Context-Aware Framework to Support Decision-Making in Production Planning". In: *Advanced Information Systems Engineering - 36th International Conference, Caise 2024, Limassol, Cyprus, June 3-7, 2024, Proceedings*, (2024), pp. 248 - 264. DOI: 10.1007/978-3-031-61057-8_15

Luca Bernardi Mario, Casciani Angelo, Cimitile Marta, Marrella Andrea "A preliminary study on Business Process-aware Large Language Models". In: *Proceedings Of The Ital-ia Intelligenza Artificiale - Thematic Workshops Co-located With The 4th Cini National*

Lab Aiis Conference On Artificial Intelligence (ital-ia 2024), Naples, Italy, May 29-30, 2024, (volume: 3762) (2024), pp. 441 - 446.

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Marrella A. "Balancing Autonomy and Trust to Enable Intelligent Robotic Process Automation". In: *Pmai 2024. Process Management In The Ai Era 2024. Proceedings Of The 3rd International Workshop On Process Management In The Ai Era (pmai 2024) Co-located With 27th European Conference On Artificial Intelligence (ecai 2024)*, (volume: 3779) (2024), pp. 2 - 4.

Casciani Angelo, Bernardi Mario L., Cimitile Marta, Marrella Andrea "Conversational Systems for AI-Augmented Business Process Management". In: *Research Challenges In Information Science - 18th International Conference, Rcis 2024, Guimaraes, Portugal, May 14-17, 2024, Proceedings, Part I*, (2024), pp. 183 - 200. DOI: 10.1007/978-3-031-59465-6_12

Agostinelli S., Benvenuti D., Marrella A., Rossi J. "DIS-PIPE: A Tool for Data Pipeline Discovery". In: *Doctoral Consortium And Demo Track 2024 At The International Conference On Process Mining 2024 (icpm-d 2024)*, (volume: 3783) (2024).

Blasilli G., Ferro L. S., Lenti S., Maggi F. M., Marrella A., Catarci T. "EDD: A Web-Based Editor for Declarative Process Models Using easyDeclare". In: *Doctoral Consortium And Demo Track 2024 At The International Conference On Process Mining 2024 (icpm-d 2024)*, (volume: 3783) (2024).

3.2.12 Theory of Deep Learning

Research lines:

- Neural Networks and Support Vector Machines

Members: AMERINI Irene, BACCINI Federica, BECCHETTI Luca, SICILIANO Federico, SILVESTRI Fabrizio (leader) and TRAPPOLINI Giovanni

PhD students: BACCIU Andrea, BETELLO Filippo, CASO Francesco, CASSARA Giulia, CUCONASU Florin, D'ERASMO Giulio, DI FRANCESCO Andrea Giuseppe, LENTI Jacopo, PIKTUS Aleksandra , PURIFICATO Antonio and WANI Farooq Ahmad

Post Docs: BUCARELLI Maria Sofia, CAMPAGNANO Cesare, PORCARO Lorenzo and RUSCIO Valeria

The RSTLess research group is a dynamic and innovative team of researchers from

Sapienza University of Rome, led by Professor Fabrizio Silvestri.
Our focus is on the cutting-edge fields of Deep Learning, Information Retrieval, Graph Neural Networks, and Natural Language Processing, with a special emphasis on Robustness, Safety, and Transparency.
The team's mission is to push the boundaries of these areas and deliver cutting-edge solutions that have a real impact on society, while ensuring the robustness, safety, and transparency of our algorithms.
Our team is made up of experts in the field, and we are constantly collaborating with other researchers, academic institutions, and industry partners to advance our understanding of these areas and to develop new, innovative solutions that meet the highest standards of robustness, safety, and transparency.

Publications

Journal papers

Bucarelli Maria Sofia, D'inverno Giuseppe Alessio, Bianchini Monica, Scarselli Franco, Silvestri Fabrizio "A topological description of loss surfaces based on Betti Numbers". In: Neural Networks, (volume: 178) (2024). DOI: 10.1016/j.neunet.2024.106465

Porcaro Lorenzo, G('(o))mez Emilia, Castillo Carlos "Assessing the Impact of Music Recommendation Diversity on Listeners: A Longitudinal Study". In: Acm Transactions On Recommender Systems, (volume: 2) (2024). DOI: 10.1145/3608487

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Mucha Wiktor, Cuconasu Florin, Etori Naome A., Kalokyri Valia, Trappolini Giovanni "TEXT2TASTE: A Versatile Egocentric Vision System for Intelligent Reading Assistance Using Large Language Model". In: Computers Helping People With Special Needs, (2024), pp. 285 - 291. DOI: 10.1007/978-3-031-62849-8_35

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3.3 Economics and Management Engineering

3.3.1 Industrial Organization and Management

Research lines:

- Economics and Management of Education and Research

- Economics and regulation of network industries
- Operations Management
- Productivity and efficiency analysis
- Project Management
- R&D, Innovation, and public policies
- Renewable Energy Sources and Environmental Policies
- Strategic Management
- Sustainability and environmental management

Members: ANNARELLI Alessandro, AVENALI Alessandro, CATALANO Giuseppe, CONTI Chiara, D'ADAMO Idiano, D'ALFONSO Tiziana, DARAIO Cinzia, DI LEO Simone, DI PILLO Francesca, FRACCASCIA Luca, GIAGNORIO Mirko, GREGORI Martina, GROSSO Chiara, MARZANO Riccardo, MATTEUCCI Giorgio, NASTASI Alberto (leader), NONINO Fabio, OROPALLO Eugenio and REVERBERI Pierfrancesco

Post Docs: QUAGLIA Giammarco and VONA Luigi

PhD students: DE SANTIS Daniele, MOLLICA Melissa, PETITTI Federico and QUAGLIERI Luca

The research activity of the group, which includes general issues in industrial economics, public policy, and management, focuses on the following research lines:

1. Economics and regulation of network industries
2. Operations management
3. Productivity and efficiency analysis
4. Project Management
5. R&D, Innovation, and public policies
6. Strategic Management
7. Sustainability and environmental management

For each research line, the main research topics are highlighted as follows:

1. **Economics and regulation of network industries**
    - Competition, regulation, investment incentives, and industrial policy in network industries, with a focus on air transport, rail transport, local public transport and utilities
    - Game-theoretic models to assess the welfare effects of access conditions to enduring economic bottlenecks, depending on the vertical industry structure, with a focus on telecommunications and transportation

- Allocation and pricing of scarce network resources
- Sharing economy and peer-to-peer platforms
- Standard cost assessment of public transport
- Efficiency and effectiveness analysis regarding local public transport
- Strategic and business aspects of rolling stock management for public transport (introduction of alternative fuel technologies)
- Changes on mobility-framework towards more sustainable solutions
- Economic benchmarking of transport modes
- Competition in passenger transportation markets
- Dynamic congestion

2. **Operations management**
   - Auction mechanism for valuable economic resources allocation with complementarity/substitutability relationships, cost analysis, top-down and bottom-up cost models
   - Operational aspects of environmental sustainability practices at both the company and the network level
3. **Productivity and efficiency analysis**
   - Theoretical, methodological, and empirical models for the assessment of efficiency, effectiveness and impact.
   - Advanced nonparametric and robust methods for the assessment of public and private services
   - Performance evaluation of academy departments and heterogeneity analysis of European higher education institutions
   - Investigations on the economics, management, and modeling of scientific research and higher education
4. **Project Management**
   - Business opportunities and social welfare resulting from an effective integration of sustainability principles inside project management practices both at corporate and project manager individual level
   - Managerial implications of project management practices and organizational aspects (e.g., informal social networks, individuals' and small groups' behavior, culture) with interest in specific emergent contexts such as industry 4.0, circular economy, and cyber security
5. **R&D, Innovation, and public policies**
   - Theoretical and empirical models applied to the analysis of the drivers of innovative performance, with a special interest in externalities, public policies' impact on R&D strategies, and welfare effects
   - Relationship between R&D investment decisions and environmental policies focusing on their role in spurring innovation

- Empirical research on innovation and diffusion of clean technologies within Europe investigating the impact of EU support
- Analysis of the interplay among competition, regulation, and the incentives to invest in product quality, with a focus on research-intensive industries
- Economic aspects of privacy regulation, in particular on the role of consumers' data in innovation processes

6. **Strategic Management**
   - Ownership and corporate governance mechanisms and their interaction with the institutional variety as drivers of firm's internationalization strategies
7. **Sustainability and environmental management**
   - Operational and business aspects of circular economy strategies, e.g., industrial symbiosis, renewable energy production, waste management, bioeconomy, industry 4.0
   - Circular business models
   - Operational and managerial aspects linked to relevant strategic transitions of companies, i.e., the servitization of business and the digital transformation of business
   - Consumer behavior towards the adoption of green innovations
   - Antecedents, outcomes, and success factors of the integration of environmental sustainability within firm strategies and innovation development
   - Effects of trade liberalization in environmental goods as a means of helping developed and developing countries alike deal with environmental problems

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). It has implemented and implements collaborations with several institutions, e.g.,: (1) the National Agency for University and Scientific Research Evaluation (ANVUR), the Ministry of Education, Universities, and Research (MIUR) concerning the evaluation of the impact of public policies for higher education and scientific research; the Ministry of infrastructures and Transport and the European Commission on the themes of the standard cost of local public transport; (3) ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) on the themes related to industrial symbiosis.

Publications

Journal papers

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Fontanella S., Fraccascia L., Nonino F., Scarnicchia A. "Sustainable business model in practice: a digital business game training for high school students". In: Proceedings Icsit, International Conference On Society And Information Technologies, (volume: 2024-) (2024), pp. 139 - 145. DOI: 10.54808/ICSIT2024.01.139

3.3.1 Industrial systems engineering

Research lines:

- Resilience Engineering and System Safety
- Maintenance management
- Inventory Management
- Human-Robot Collaboration
- Socio-Technical Safety
- Supply Chain Management
- Health and safety
- Smart factory

Members:COSTANTINO Francesco (leader), COLABIANCHI Silvia

PhD students: SABETTA Nicolò

The research group focuses on the study and management of complex industrial systems, with particular attention to safety, sustainability, and digitalization. Its activities span several research areas, ranging from the modeling of socio-technical systems through the lens of resilience engineering, to the application of enabling technologies (e.g., artificial intelligence, collaborative robots, virtual reality, etc.) for training and prevention in occupational health and safety, and the development of digital solutions for predictive maintenance, logistics management, supply chain optimization, and smart manufacturing.

Publications

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Conference proceedings

Bentivenga Rosina, Bernabei Margherita, Carli Marco, Colabianchi Silvia, Costantino Francesco, Ferrarotti Anna, Neri Michael, Pietrafesa Emma, Sorrentino And Sara Stabile Edvige "Advancing Occupational Safety and Health training: a Safety-II integration of the ADDIE model for virtual reality". In: Lecture Notes In Networks And Systems, (2024).

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Bentivenga Rosina, Bernabei Margherita, Carli Marco, Colabianchi Silvia, Costantino Francesco, Ferrarotti Anna, Neri Michael, Pietrafesa Emma, Sorrentino Edvige, Stabile Sara "Transforming Training With New Enabling Technologies: A Proposal To Verify The Efficacy Of Virtual Reality Tools In The Occupational Health And Safety Sector". In: Lecture Notes In Networks And Systems, (2024).

3.4 Operations Research

3.4.1 Combinatorial Optimization

Research lines:

- Computational Biology and Bioinformatics
- Data Mining and Classification
- Graph theory and Optimization
- Information Reconstruction
- Polyhedral Combinatorics
- Portfolio Optimization
- Robust Optimization
- Satisfiability in Propositional Logic
- Scheduling and Job-shop Scheduling

- Telecommunication Network Design

Members: BRUNI Renato, FURINI Fabio and SASSANO Antonio (Former)

Combinatorial Optimization is a thriving field at the forefront of discrete mathematics and theoretical computer science. Its main focus is the efficient discovery of specific data structures and optimal set of objects into a finite (but large) collection of feasible solutions. 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, algorithms for the optimal and robust determination of control parameters of vehicles or spacecrafts.

The group is currently cooperating with the Italian National Statistic Office (Istituto Nazionale di Statistica ISTAT), the Italian Authority of Telecommunications (AGCOM), Fondazione "Ugo Bordoni". In the last 10 years, the group has been involved in a large number of national and international projects and 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. 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 clustering and imputation of Educational Institutions in the study of educational systems; 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.

Publications

Journal papers

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Calamita Alice, Ljubić Ivana, Palagi Laura "Benders decomposition for congested partial set covering location with uncertain demand". In: , (2024). DOI: 10.48550/arXiv.2401.12625

3.4.2 Continuous Optimization

Research lines:

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

Members: CROELLA Anna Livia, DE SANTIS Alberto, DI PILLO Gianni (former), DOSE Valerio, FACCHINEI Francisco (leader), LIUZZI Giampaolo, LUCIDI Stefano, PALAGI Laura, PICCIALLI Veronica, ROMA Massimo, SAGRATELLA Simone, SALZO Saverio, SCIANDRONE Marco, SUDOSO Antonio Maria and DE SANTIS Marianna

PhD students: BATTISTA Federico (Former), BORESTA Marco (Former), CALAMITA Alice, CESARONI Edoardo, CIOCCI Ilaria, COPPOLA Corrado, D'AVINO Arcangelo, D'ONOFRIO Federico, GIANCOLA Francesca, MARIOSA Raffaele, MEROLLA Davide, OTTAVIANI Eleonora, PALA Anna Laura, PANNONE Alessandro, PATRIA Daniele, PIERMARINI Christian, PINTO Diego Maria (Former), PRIORI Gianluca, RAUCO Giorgia, RICCARDI Giulia, SACCUCCI Lorenzo, SASSO Valerio, SCARPONI Giulio, SCUPPA Diego, TOMASSINI Riccardo and TRONCI Edoardo Maria (Former)

Post Docs: MONACI Marta and BRILLI Andrea

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, which 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 modeling 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.
- Algorithms for bilevel optimization problems in machine learning using gradient-based and implicit function approaches.
- Stochastic optimization methods under heavy-tailed noise and with guarantees in high probabilities. Stochastic and randomized proximal spitting methods.

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.

Publications

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3.5 Systems and Control Engineering

3.5.1 Networked Systems

Research lines:

- Control Applications
- Control of Networks
- Control under Communication Constraints
- Modeling, Filtering and Optimal Control of Communication Networks
- Reinforcement Learning
- Wireless and Sensor Networks

Members: DE SANTIS Emanuele, DELLI PRISCOLI Francesco, DI GIORGIO Alessandro (leader), GIUSEPPI Alessandro, LIBERATI Francesco and PIETRABISSA Antonio (leader)

PhD students: ATANASIOUS Mohab , BALDISSERI Federico, BECCHETTI Valentina, DI PAOLA Antonio, DONSANTE Manuel, GENTILE Simone, IMRAN Muhammad, MAIANI Arturo and TANTUCCI Andrea

Post Docs: MENEGATTI Danilo and WRONA Andrea

The Networked Systems research group, led by Proff. Alessandro Di Giorgio and Antonio Pietrabissa, aims at developing control methodologies in the context of networked systems. Besides classical control methods, such as model predictive control, optimal control and robust control, distributed non-cooperative control methods are being developed on the ground of mean-field game theory as well as learning methodologies such as reinforcement learning and deep reinforcement learning. Application areas of interest are communication networks, energy distribution networks, cyber-physical security in interconnected systems, bioengineering (e.g., brain connectivity).

The Networked Systems group members cooperate with researchers from national and international academia and industries. The members of the group are still cooperating with Alberto Isidori (Hemeritus), founder member of the group. Among other collaborations, currently the group's members are working with ETRI (Electronics and Telecommunications Research Institute), which is the most important research institute in South Korea, CEA (Commissariat à l'énergie atomique et aux énergies alternatives), which is the French research organisation in the areas of energy, security, information technologies and health technologies, the Université libre de Bruxelles (ULB), Belgium, the University of Coimbra, Portugal, Tunghai University, Taiwan. See the list of the group's external members and of the group's publications for further information.

Currently, the main research topics of the group are the ones listed below.

- Future Internet

The group's research supports a Future Internet vision, on the ground of the participation in the large FI-WARE EU-funded project concerning the Future Internet technology foundation and in projects on 5G communications, to develop a technology-independent distributed framework including coordinated control algorithms. These algorithms, based on homogeneous metadata describing the network and user status, manage the network resources and services to maximize the resource exploitation while satisfying the user requirements. The adopted methodologies include model-free learning, multi-agent systems, cross-layer/cross-network optimization, context awareness, data fusion.

- e-Health

The focus of the research activities of the group is related to the design and development of Intelligent Systems to support medical workers in the diagnosis and treatment processes. The group has studied several solutions for medical imaging analytics to provide medical operators with detailed reports of the anomalies and key features detected inside a decision support system. The group has developed customised algorithms for Federated Learning, to allow a GDPR-compliant knowledge sharing solution among networked clinical institutions by enabling the training of distributed Artificial Intelligence systems. Recent research activities focus also on the design of predictive and individualised control algorithms for the insulin treatment of patients using an artificial pancreas.

- Smart Energy

The research group tackles several control problems in the smart grid and power systems domain, including: control of renewable energy sources, active demand and demand side management in the residential and commercial sectors, algorithms for smart charging control of plug-in electric vehicles, integration of storage and other distributed energy resources into the grid. The research group has cooperated with several italian and european research centers, universities and industries in many national and european research projects, where it has developed smart grid control algorithms mostly based on model predictive control and nonlinear control techniques (e.g., feedback linearization).

- Space

Within this topic, the research group aims at developing control methodologies in the context of space-related applications, such as satellite communication networks along with their interaction with terrestrial (wired and wireless) ones, satellite networks used for emergency prevention, satellite launchers, sensor networks for planetary explorations. The control methodologies are applied in several international research projects funded by ESA and EU and range from classical feedback control of time-delay systems for congestion control problems to distribued non-cooperative control for load balancing and routing problems and deep reinforcement solutions for admission control problems.

The group members are involved in the activities of the Consortium for the Research in Automation and Telecommunications (CRAT), whose members are University of Rome Sapienza, Politecnico di Bari, University of Sannio, Thales Alenia Space Italia and TopNetwork. The aim of CRAT is to carry out applied research in the context of National and European projects and to favour the birth of start-ups. The Sapienza start-up Ares2t was funded by members of the Networked System group on the ground of research in the field of smart grids and smart charging of electric vehicles.

On-going research projects

- SHIELD, Strategic Health Initiatives for Effective Disease Prevention (managed by CRAT), December 2024 - November 2028,
- ARIES-DEMO, Advanced multi-Rat Integrated multi-sensors solution for Emergency prevention, detection and response operationS - Demonstrator (managed by CRAT), October 2024 - July 2026
- CADUCEO, Cloud platform for intelligent prevention and diagnosis supported by artificial intellegent solutions, January 2021 - December 2024, MISE.
- NANCY, An Artificial Intelligent Aided Unified Network for Secure Beyond 5G Long Term Evolution (managed by CRAT), January 2022 - December 2025, HORIZON-JU-SNS-2022.
- HyDEMO, HydRON Demonstrator System Phase A/B1", January 2022 - (expected) December 2023 (managed by CRAT), European Space Agency (ESA), HydRON Demonstration System (DS).

Publications

Journal papers

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Becchetti Valentina, Atanasious Mohab M. H., Menegatti Danilo, Baldisseri Federico, Giuseppi Alessandro "Dynamic Mode Decomposition for Individualized Model Predictive Control with Application to Type 1 Diabetes". In: Proceedings Of 2024 32nd Mediterranean Conference On Control And Automation (med), (2024). DOI: 10.1109/med61351.2024.10566271

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3.5.2 Nonlinear Systems and Control

Research lines:

- Delay Systems
- Discrete-time and Sampled Data Systems
- Distributed estimation
- Epidemic modeling and control
- Feedback linearization
- Hybrid Systems
- Multi-Agent and Multi Robot Systems
- Nonlinear observers
- Optimal Control and Stochastic Systems
- Optimal control for resource management
- Optimal Filtering
- Stochastic stabilisation
- Systems analysis and control

Members: BATTILOTTI Stefano (leader), BENVENUTI Luca, CALIFANO Claudia, DI GIAMBERARDINO Paolo, IACOVIELLO Daniela, MATTIONI Mattia and MONACO Salvatore

Research on nonlinear systems and control at the University of Rome La Sapienza has been active since the early 70s and, historically, has played a major role worldwide.

The geometric approach to nonlinear feedback design marked the beginning of a new area of research which, in the subsequent decades, has profoundly influenced the development of the entire field. The concepts of feedback equivalence and zero dynamics, their properties and implications are perhaps the most frequently used concepts in nonlinear feedback design. The natural evolution of the geometric approach from the study of systems evolving on Lie groups, with numerous applications to the control of spacecrafts and mobile robots, to robust regulation under state and output measurements feedback of systems possessing unstable zero dynamics, the use of filtered Lyapunov functions for robust stabilization, the control of networked systems in presence of limited information, till the control of nonlinear delayed systems, 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 outcomes 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. From the results on feedback linearization, stabilization, regulation, observer theory, new research lines are in the direction of hybrid, networked and Hamiltonian dynamics. Particular attention is devoted to the settlement of executable algorithms for computing the proposed solutions. Measurements devices, algorithms, data handling and transmission represent critical aspects in any distributed control problem. The number of devices, their location, the energy consumption, the data-communication links, the distributed data handling, multi-consensus, load balancing, and quality evaluation are nowadays classical concepts 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.

Epidemic modeling, analysis and control is a further research line developed by the group. The methodologies of mathematical modeling and system analysis are applied to the study of specific epidemic diseases, like the HIV/AIDS, the measles and, recently, the COVID-19. The research goes through the introduction of ad hoc models, identified by using real data, the characterization of the Reproduction Number, along with its relation with the most significant epidemic parameters (contact rates, death rates, time constants of infections, etc), the definition of suitable optimal intervention policies with the possible control corresponding to vaccination, prevention with informative campaign, medication, quarantine and isolation, as in the recent COVID-19 emergency. Specific characterizations of each infection, like, for the case of COVID-19, the phenomenon of asymptomatic subjects who do not have evidence of the infection but can transmit it, or the age dependent dangerousness of the disease, are faced and analysed in view of control actions. The same kind of modeling analysis and control is successfully applied to computer viruses and cybersecurity. Theoretical aspects (singular control) as well as the applications in different fields (for example dynamics on unemployment) of optimal control are also considered.

The applicative aspects of these research activities are carried out at the Systems and Control Laboratory, founded in 1995. Members of the Nonlinear Systems and Control group have been actively serving in the control community in technical committees and as associate editors for the major journals in the area and conference editorial boards as for both IEEE CSS, IFAC and EUCA.

The research activities, as testified by the scientific production, are developed in collaboration with several national and international institutes as the Laboratoire des Signaux et Systèmes (CNRS, Gif sur Yvette), IRCCyN (CNRS, Nantes), Fondazione Santa Lucia , Cosync Lab (Sapienza University of Rome) and the company BrainTrends, Istituto di Analisi dei Sistemi e Informatica (IASI- CNR) for the modeling, analysis and control of epidemiological models, Universidade do Porto, Centro di Sistemi di Elaborazione e Bio-Informatica (Campus Biomedico), McKelvey School of Engineering (Washington University of St. Louis). Those collaborations also encourage international research training and orientation, with PhD double degrees delivering, in the context of an ad hoc binational program ELISA, which involves Italian and French Institutions.

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Normand-cyrot D., Monaco S., Mattioni M., Moreschini A. "Passivity Techniques and Hamiltonian Structures in Discrete Time". In: Springer Proceedings In Mathematics And Statistics, (2024), pp. 327 - 352. DOI: 10.1007/978-3-031-51049-6_15

Usmani Adeel, Iacoviello Daniela, Zubair Muhammad "Adaptive Terminal Sliding Mode and Synergetic Control for Torque Management in Electric Vehicle

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Iovine A., Mattioni M., Tedeschi G. "Sampled-Data String Stability for a Platoon of heterogeneous Vehicles via a Mesoscopic Approach". In: 2024 European Control Conference, Ecc 2024, (2024), pp. 3364 - 3369. DOI: 10.23919/ECC64448.2024.10591238

3.5.3 Robotics

Research lines:

- Haptic and Locomotion Interfaces
- Humanoid Locomotion
- Medical Robotics
- Mobile Robots
- Motion and Trajectory Planning
- Physical Human-Robot Interaction
- Planning and Control of UAVs
- Robot Learning for Planning and Control
- Robot Modeling and Identification
- Sensor-based Reaction and Planning
- Soft Robotics
- Vision-based Control
- Whole-Body Control of Humanoids

Members: CRISTOFARO Andrea, DE LUCA Alessandro (leader), DE LUCA Alessandro, DE SANTIS Emanuele, FRANCHI Antonio, LANARI Leonardo, ORIOLO Giuseppe, SCIANCA Nicola and VENDITTELLI Marilena

PhD students: BELVEDERE Tommaso (Former), CAPOTONDI Marco (Former), CAPPELLINI Guglielmo, CASTELMARE Mattia, CIPRIANO Michele (Former), D'ORAZIO Francesco, GOVONI Lorenzo, HABIB Andrew, MOSLEMI Mohammad Mahdi, PUSTINA Pietro (Former), SMALDONE Filippo Maria (Former), TARANTOS Spyridon (Former) and VICECONTE Paolo Maria (Former)

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: control of manipulators with flexible elements (elastic joints, flexible links, variable stiffness actuation); hybrid force/velocity and impedance control of manipulators and aerial robots 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; stabilization of underactuated robots; control-based motion planning for mobile manipulators; motion planning and control of locomotion in humanoid robots; sensor-based navigation and exploration in unknown environments; safe control of physical human-robot collaboration; sensory supervision of human-robot interaction; image-based visual servoing; control and visual servoing for unmanned aerial vehicles; multi-robot decentralized control, estimation, coordination and mutual localization.

Most of our research activities undergo experimental validation in the DIAG Robotics Lab. The current equipment consist of 5 articulated manipulators (a 6R Universal Robots UR10, a 7R Franka Emika Research 3, two 7R ABB single arm YuMi, and a 6R KUKA KR5 industrial robot), 5 mobile robots (a TIAGo wheeled mobile manipulator with a 7 DoF arm by PAL Robotics, a OP3 small-size humanoid by ROBOTIS, a TITA wheeled legged robot by Direct Drive Tech, a Lite3 quadruped robot by Deep Robotics, and a G1 humanoid robot by Unitree robotics), 2 flying UAV (a Hummingbird and a Pelican quadrotor UAVs by AscTec), two haptic interfaces with 3D force feedback (Geomagic Touch), and an underactuated system (Pendubot by Quanser). 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 two HMDs (Oculus Rift). In the past, we have designed and built a two-link flexible manipulator (FlexArm) and a differentially-driven wheeled mobile robot (SuperMARIO).

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