DIS - Research areas

Algorithm Design and Engineering

Artificial Intelligence and Knowledge Representation

Combinatorial Optimization

Computer Graphics, Computer Vision and Perception

Computer Networks and Pervasive Systems

Continuous Optimization

Data Management and Service-Oriented Computing

Distributed Systems

High Performance and Dependable Computing Systems

Human-Computer Interaction

Hybrid Control Systems

Industrial Organization and Management

Modeling, Identification, and Control in Biological and Biomedical Systems
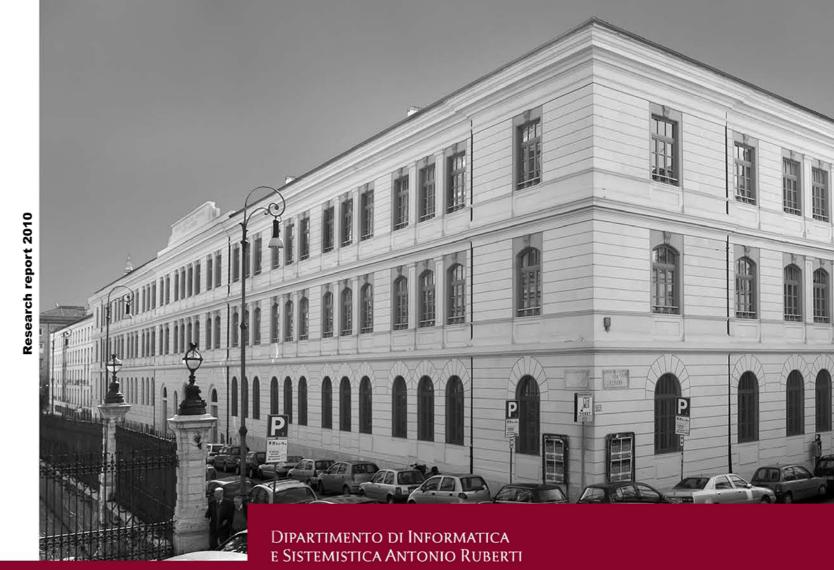
Multi-Agent and Multi-Robot Systems

Networked Systems

R&D, Innovation, and Internationalization

Robotics

Robust and Nonlinear Control

Web Algorithmics and Data Mining

Research report 2010

DIPARTIMENTO DI INFORMATICA
E SISTEMISTICA ANTONIO RUBERTI

SAPIENZA
UNIVERSITÀ DI ROMA

Dipartimento di Informatica e Sistemistica Antonio Ruberti

Research report 2010

**Dipartimento di Informatica e Sistemistica
Antonio Ruberti**
http://www.dis.uniroma1.it

Dipartimento di Informatica e Sistemistica Antonio Ruberti
Sapienza Università di Roma

Research report 2010

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1 Introduction

The present report provides an overview of the research carried out at the Department of Computer and System Sciences Antonio Ruberti (DIS) of the Sapienza University of Rome, during the year 2010.

DIS 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 DIS 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.

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

Basic research is the main goal of DIS, with a strong emphasis on interdisciplinary research, on applications that stimulate basic research, and with a specific attention to technology transfer and dissemination of results.

Collaborations are maintained with researchers in other university departments, research institutions and companies, in Italy and abroad.

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

The faculty of DIS in 2010 consists of 29 full professors, 19 associate professors, and 19 assistant professors (ricercatori). They provide education at the undergraduate and graduate levels to several programs of the two schools of engineering at Sapienza (*Facoltà di Ingegneria dell'informazione, Informatica e Statistica* and *Facoltà di Ingegneria Civile ed Industriale*), with main responsibility in the curricula in informatics, systems and control, and engineering management. Teaching activities are not illustrated in this report; a description may be found at `http://www.dis.uniroma1.it` under the entry "Teaching".

Furthermore, DIS offers two PhD programs, and cooperates with three PhD programs offered by other departments. They are briefly described in Section 2 of this report.

Research activities at DIS are organized in 19 research areas. This organization is reflected in the structure of Section 3, where the research areas are described with a short description of their main research lines, together with the list of people involved, and the collection of publications appeared in 2010.

2 General Information

2.1 Location

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

2.2 Facilities

Library

The DIS library was first established in 1970 at the Istituto di Automatica. In 2007 the library moved to the building in Via Ariosto 25, where two reading rooms are available for users. Approximately 11,000 books and conference proceedings, plus 392 journals subscriptions (94 of which are currently active), and 784 on-line journals are currently available. The DIS library provides the department with access to information in its many formats in order to support teaching, learning, research, and service functions. The library facilities are also available to non-members of the department and students.

During the year 2010, the DIS library continued the organization of the series of invited lectures *Incontri al Chiostro*, under the supervision of professors Marilena VENDITTELLI and Alberto MARCHETTI SPACCAMELA. The lectures of 2010 were:

Gianni ZANARINI	Ghost in the machine: l'intelligenza artificiale al cinema.	May 10, 2010
Gabriel RUGET	What makes us move through artworks (under/above storytelling)?	May 26, 2010
Paolo ZELLINI	Numero e logos.	Dec. 15, 2010

Laboratories

DIS hosts several research and educational laboratories. The following list reports name, location, purpose, and the person in charge for each of them.

ALCOR - Cognitive Robotics Laboratory
Via Ariosto 25 - basement
The main thrust in this laboratory is the development and experimental validation of advanced planning and control techniques for industrial and service robots.
Web: `http://www.dis.uniroma1.it/~alcor`
Head: Fiora PIRRI

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

Head: Camil DEMETRESCU

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

BiBiLab - Bioengineering and Bioinformatics Laboratory
Via Ariosto 25 - basement
The laboratory is devoted to the study of the neuroengineering field and the development of applications based on Brain Computer Interfaces (BCI). Field tests on real patients are performed in collaboration with the Department of Human Physiology and Pharmacology and with the IRCCS "S. Lucia".
Head: Serenella SALINARI

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

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

Joint Lab on Security Research
Via Ariosto 25 - wing B1
The Joint-Lab on security research with Sapienza Innovazione has the mission to create a critical mass of researchers of La Sapienza around system and software security in complex environments. Results of research of the joint-lab are heavily oriented toward innovation and the creation of new technology companies.
Web: `http://www.dis.uniroma1.it/~labsec`
Head: Roberto BALDONI

Management Engineering Laboratory
Via Ariosto 25 - room 122 and 123, wing A1
The laboratory is devoted to the development of mathematical models and solution algorithms for Management Engineering problems.
Web: `http://www.dis.uniroma1.it/~or/lab.html`

Head: Massimo ROMA

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

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

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

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

Software Development (Thesis Students) Laboratory
via Ariosto 25 - rooms A1 and A2
The laboratory is devoted to the training of students on the design and implementation of software systems.
Head: Massimo MECELLA

Systems and Control Laboratory
Via Ariosto 25 - basement
The laboratory is devoted to the development and experimental verification of new control strategies.
Web: `http://labsis.dis.uniroma1.it/LSW_R2/`

Head: Salvatore MONACO

Wireless Sensor Networks Laboratory
Via Ariosto 25 - basement
The laboratory is devoted to the development and experimental verification of protocols
and algorithms for WSNs.
Web: `http://wiserver.dis.uniroma1.it/cms/`
Head: Andrea VITALETTI

Additional information on the DIS laboratories may be found at `http://www.dis.uniroma1.it/`.

Educational Laboratories

DIS manages two educational laboratories of the School of Engineering, used for hands-
on teaching and for self-studying. The laboratories are named after Paolo Ercoli, the
founder of the Computer science component of the department. Educational laborato-
ries are on the web at the address `http://www.dis.uniroma1.it/`.

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

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

2.3 People

Director - Luigia CARLUCCI AIELLO (up to December 12, 2010)
Claudio LEPORELLI (from December 13, 2010)

Administration Head - Maria Pia VANDILLI (up to June 30, 2010)
Giovanna BIANCO (from July 1, 2010)

Faculty

Professors
Giorgio AUSIELLO
Roberto BALDONI
Stefano BATTILOTTI
Carlo BRUNI
Luigia CARLUCCI AIELLO
Tiziana CATARCI
Bruno CICIANI
Alessandro DE CARLI (up to October 2010)
Giuseppe DE GIACOMO
Alessandro DE LUCA
Francesco DELLI PRISCOLI
Gianni DI PILLO
Francisco FACCHINEI
Claudio GORI GIORGI
Luigi GRIPPO
Alberto ISIDORI
Maurizio LENZERINI
Stefano LEONARDI
Claudio LEPORELLI
Stefano LUCIDI
Alberto MARCHETTI SPACCAMELA
Salvatore MONACO
Umberto NANNI
Daniele NARDI
Alberto NASTASI
Maria Luisa PETIT TARASCON
Fiora PIRRI
Francesca SANNA RANDACCIO
Antonio SASSANO
Marco SCHAERF

Associate professors
Luca BENVENUTI
Fabrizio D'AMORE
Camil DEMETRESCU (from December 2010)
Alberto DE SANTIS
Lorenzo FARINA
Domenico LAISE
Leonardo LANARI
Paolo LIBERATORE
Carlo MANNINO
Giuseppe ORIOLO
Laura PALAGI
Francesco QUAGLIA
Pierfrancesco REVERBERI
Massimo ROMA
Riccardo ROSATI
Serenella SALINARI
Silvio SALZA
Giuseppe SANTUCCI
Marco TEMPERINI

Assistant professors (ricercatori)
Alessandro AVENALI
Luca BECCHETTI
Roberto BERALDI
Claudia CALIFANO
Claudio DE PERSIS
Camil DEMETRESCU (up to December 2010)
Paolo DI GIAMBERARDINO
Giorgio GRISETTI (from November 2010)
Daniela IACOVIELLO
Luca IOCCHI
Domenico LEMBO
Giorgio MATTEUCCI
Massimo MECELLA
Carlo Maria MEDAGLIA (from November 2010)
Fabio NONINO (from November 2010)
Antonio PIETRABISSA (from November 2010)
Leonardo QUERZONI
Roberta SESTINI
Marilena VENDITTELLI
Andrea VITALETTI

Staff

Research associates and post docs   *Administration staff*
Carola AIELLO   Amelia ARRICALE
Aris ANAGNOSTOPOULOS   Giovanna BIANCO (from July 2010)
Laura ASTOLFI   Flavia CAGNIZI
Anna BELARDINELLI   Antonietta CANGELLI
Vincenzo BONIFACI   Ugo CINELLI (from October 2010)
Silvia BONOMI   Beatrice DE CARLO
Ilaria BORDINO   Giuditta FILOMENA
Daniele CALISI   Sabrina GIAMPAOLETTI
Silvia CANALE   Tiziana VALENTINI
Marco CASTRUCCI   Maria Pia VANDILLI
Andrea D'AGOSTINI
Massimiliano DE LEONI   *Technical staff*
Alessandro DI GIORGIO   Anna Paola DI RISIO (on leave)
Luigi LAURA   Giuseppe FILACI
Giorgia LODI   Marcello PANI
Sara MATTIA   Tiziana TONI
Silvano MIGNANTI
Papadakis PANAGIOTIS   *Auxiliary services*
Fabio PATRIZI   Pia BONANNI (up to November 2010)
Andrea PENNISI   Antonio SIMEONI
Antonella POGGI
Francesco RINALDI   *Library*
Marco RUZZI   Laura ARMIERO
Piotr SANKOWSKY   Roberta PROIETTI SEMPRONI (from November 2010)
Vincenzo SURACI
Chiara TOGLIA
Vittorio Amos ZIPARO

2.4   Doctoral Programs

DIS directly hosts the PhD programs in Computing Science and Engineering and in Systems Engineering. Moreover, DIS cooperates in the PhD programs in Bioengineering, hosted by the Department of Electric, Computer and System Sciences) of the University of Bologna, in Operations Research, hosted by the Department of Statistical Sciences of the University of Rome "La Sapienza", and in Economics and Management of Technology hosted by the Department of Management Engineering of the University of Bergamo.

Bioengineering

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

PhD students (working at DIS)

<table>
<tr><td>XXV course</td></tr>
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New admissions for the XXVI course are:

Pietro ARICÒ
Francesca SCHETTINI

Computing Science and Engineering

The council of professors of the PhD program in Computing Science and Engineering is coordinated by Roberto BALDONI.
The research topics are: theory of algorithms, computer systems, databases, programming languages, theoretical computer science, image processing, artificial intelligence, cognitive robotics, VLSI, computational logics, performance evaluation, distributed software architectures, computer networks and security.

PhD students

XXI course	XXII course	XXIII course
Alessio PASCUCCI	Domenico Davide LAMANNA Shah Rukh HUMAYOUN	Andrea CARBONE Ugo Maria COLESANTI Matteo LEONETTI Stefano MARRA Matia PIZZOLI Gabriele RANDELLI

XXIV course	XXV course
Lorenzo BERGAMINI Pierangelo DI SANZO Luca FILIPPONI Letizia MARCHEGIANI Roberto PALMIERI Marco PLATANIA Domenico Fabio SAVO	Adriano CEROCCHI Riccardo DE MASELLIS Claudio DI CICCIO Ricardo DODDS Paolo FELLI Donatella FIRMANI Mario GIANNI Andrea MARRELLA Ida MELE Luca MONTANARI Hani QUSA Roberto VITALI

New admissions for the XXVI course are:

  Leonardo ANIELLO
  Floriana DI PINTO
  Francesco LEOTTA
  Khalil M.H. AL MASSRI
  Alessandro PELLEGRINI
  Sebastiano PELUSO
  Diego RUGHETTI
  Alessandro RUSSO
  Suzanne VAN DE STER

Economics and Management of Technology

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

PhD students (working at DIS)

XXII course	XXV course
Anna D'ANNUNZIO	Tiziana D'ALFONSO

Operations Research

The council of professors of the PhD program in Operations research is hosted by the Department of Statistical Sciences of the University of Rome "La Sapienza" and is coordinated by Stefano LUCIDI.
The research topics are: Combinatorial optimization, nonlinear programming, network design, neural networks, logistics, management systems, and industrial systems economy.

PhD students (working at DIS)

XXIII course	XXIV course	XXV course
Serena TEBALDO	Marianna DE SANTIS	Stefania DE ANGELIS
	Andrea IANNI	Vittorio LATORRE
	Carla MICHINI	Simone SAGRATELLA
	Mauro PIACENTINI	

New admissions for the XXVI course are:

  Alessandra REALE

Systems Engineering

The council of professors of the PhD program in Systems Engineering is coordinated by Carlo BRUNI.

The research topics are: Systems theory, automatic control, nonlinear systems, intelligent control, robotics, flexible manufacturing systems, biosystems, modelling, identification, optimal control, and resource management for wireless systems.

PhD students

XXII course	XXIII course	XXIV course	XXV course
Enrico GENTILI	Laura PIMPINELLA	Laura FOGLIATI	Andrea ABELLI
	Filippo RODRIGUEZ	Fabrizio FLACCO	Andrea FIASCHETTI
	Valentina RUSSO	Lorenzo LAMPARIELLO	Pietro PELITI
	Fernando TIEFENSEE	Federico PAPA	Guido ODDI
	Marco VEROLI	Mattia PETRUCCIANI	Marco PAOLETTI
		Simone SAGRATELLA	Daniele PUCCI
		Paolo STEGAGNO	Antonio D'ANGELO

New admissions for the XXVI course are:

Giorgia CHINI
Andi PALO
Martina PANFILI
Margherita PETROCCHI
Lorenzo ROSA

PhD theses completed in 2010

Computing Science and Engineering

Alberto VALERO GOMEZ
Evolutionary design of human-robot interfaces for teaming and mobile robots in exploration missions.
Advisor: Danele NARDI
January 2010

Domenico Daniele BLOISI
Visual tracking and data fusion for automatic video surveillance.
Advisor: Luca IOCCHI
February 2010

Daniele CALISI
Mobile robots and vehicles motion systems: a unifying framework.
Advisor: Daniele NARDI
February 2010

Silvia BONOMI
Implementing distributed computing abstractions in presence of churn.
Advisor: Roberto BALDONI
June 2010

Ilaria BORDINO
Graph mining and its applications to web search.
Advisor: Stefano LEONARDI
June 2010

Operations research

Fabio D'ANDREAGIOVANNI
Pure 0-1 programming approaches to wireless network design.
Advisor: Carlo MANNINO
January 2010

Systems Engineering

Simone ASNAGHI
Modelli matematici nei sistemi metabolici: analisi del metabolismo del glucosio in situazioni normali e patologiche.
Advisor: Serenella SALINARI
April 2010

Marco CASTRUCCI
Fault-tolerant routing in next generation home networks.
Advisor: Francesco DELLI PRISCOLI
April 2010

Alessandro DI GIORGIO
Non linear control of a wind turbine driven doubly fed induction generator for ancillary services and standard steady-state operation.
Advisor: Francesco DELLI PRISCOLI
April 2010

Antonio FRANCHI
Decentralized methods for cooperative task execution in multi-robot systems.
Advisor: Giuseppe ORIOLO
April 2010

Andrea MERCURIO
Generation portfolio optimization by means of genetic algorithms and stochastic methods.

Advisor: Francesco Delli Priscoli
April 2010

Fernando Tiefensee
Méthodes asymptotiques pour la commande des systémes non linéaires échantilloinnés.
Advisor: Marie Dorothée Normand-Cyrot and Salvatore Monaco
October 2010

Visiting Scientists

DIS hosts visiting scientists and scholars from all over the world. Here we list the visitors that spent at least one month at DIS during 2010.

Amos Fiat, Tel Aviv University, Israel (February)
Leen Stougie, VU University and Centrum Wiskunde & Informatica, Amsterdam (April)
Arthur ter Hofstede, Queensland University of Technology in Brisbane, Australia (May)
Yves Lesperance, York University, Toronto, Canada (June-July)
Sebastian Sardina, RMIT University, Melbourne, Australia (July)
Hector Geffner, Universitat Pompeu Fabra, Barcelona, Spain (July)

2.5   Contracts

DIS carries on its research on contracts with public funding agencies and companies. Some of them continue over more than one year. Contractor, funding to DIS in Euro, title, project leader and duration of each contract are detailed in the list below. The titles of the contracts with Italian entities are reported in Italian.

Contracts with the European Union (E.U.)

- FP7-IP, € 193.520, AEOLUS, Algorithmic principles for building efficient overlay computers, A. Marchetti Spaccamela (up to 28/02/10)

- FP7-CSA, € 54.420, PANORAMA, Pervasive adaptation network for the organization of the research agenda and the management of activities, A. Marchetti Spaccamela (up to 31/01/11)

- FP7-CP, € 200.000, FRONTS, Foundations of adaptive networked societies of tiny artifacts, A. Marchetti Spaccamela (up to 31/01/11)

- FP7-CP, € 256.512, P2P-NEXT, Next generation peer-to-peer content delivery platform, F. Delli Priscoli (up to 31/12/11)

- FP7-CSA, € 20.491, VisMaster CA, visual analytics mastering the information age, G. Santucci (up to 31/07/2010)

- FP7-CP, € 570.000, SM4All, Smart homes for all: an embedded middleware platform for pervasive and immersive environments for all, R. Baldoni (up to 31/08/2011)

- FP7-CP, € 435.000, ACSI, Artifact-centric service interoperation, G. De Giacomo (up to 31/5/2013)

- FP7-CP, € 729.424, NIFTi, Natural human-robot cooperation in dynamic environments, F. Pirri (up to 31/12/2013)

- FP7-NOE, € 297.600, PROMISE, Participative research laboratory for multimedia and multilingual information systems evaluation, G. Santucci (up to 31/8/2013)

- FP7-Marie Curie IIF, € 158.758, SNAPS, Social networks: algorithms, privacy and security, S. Leonardi (up to 31/5/2012)

- FP7-IRSES, € 18.000, EUSACOU, European south american network on combinatorial optimization under uncertainty, A. Marchetti Spaccamela (up to 31/7/2014)

- FP7-CP, € 62.680, GreenerBuilding, an ubiquitous embedded systems framework for energy-aware buildings using activity and context knowledge, M. Mecella (up to 31/8/2013)

- FP7-CP, € 348.880, Smart-Vortex, scalable semantic product data stream management for collaboration and decision making in engineering, T. Catarci (up to 30/09/2014)

- FP7-SME, € 330.000, Collective, emerging communities for collective innovation: ict operational tool and supporting methodologies for sme associations, C. Leporelli (up to 31/12/2012)

- ERC-STG, € 332.200, PAAl—Practical approximation algorithms, S. Leonardi (up to 30/11/2014)

- ARTEMIS, € 122.430, pSHIELD, Pilot embedded systems architecture for multi-layer dependable solutions, F. Delli Priscoli (up to 31/5/2011)

- ARTEMIS, € 206.433, SOFIA: Smart objects for intelligent applications, R. Baldoni (up to 31/12/2010)

- EUREKA Eurostars, € 110.500, BLEND: Blending technologies for ubiquitous real-time data access, R. Baldoni (up to 2/5/2012)

- EUREKA Eurostars, € 75.000, pharmaAID, A. Vitaletti (up to 31/12/2011)

- LLP Leonardo da Vinci, 45.114, Understand IT, M. Temperini (up to 26/12/2012)

- ENIAC, € 85.000, MODERN: Modeling and design of reliable nanoelectronics devices – G. Di Pillo (up to February 2012)

- FP7-People/2009-IIPP, € 83.500, MANON: Methods for advanced multi-objective optimization of complex nanoscale circuits, G. Di Pillo (up to September 2013)

Contracts with Italian Institutions

- MIUR, € 33.585, SICURA - Sicurezza per l'interazione del contatto tra umani, robot e ambiente, A. De Luca (up to 21/09/10)

- MIUR, € 28.000, PRIN: Ottimizzazione nonlineare, disequazioni variazionali e problemi di equilibrio, G. Di Pillo (up to 21/09/2010)

- Fondazione S. Lucia, € 81.000, Progetto ARISLA Brain-computer interface devices to support individual autonomy in locked-in individuals, M. Mecella (up to 31/10/2013)

- Herzum Software Srl, € 56.250, Piano innovazione aziendale (PIA) relativo al progetto di ricerca e sviluppo tecnologico "COSMFactory", M. Mecella (up to 19/01/-2012)

- ASI – Agenzia Spaziale Italiana, € 294.735, SARFIRE – Spaceborn SAR imagery and environmental data fusion for the dynamical evaluation of land regions susceptibility to fire, F. Pirri (up to 09/02/2012)

- Regione Lazio and Università La Sapienza, € 728.400, Convenzione per gli interventi di riqualificazione dei laboratori di ricerca, il loro ammodernamento e l'acquisizione di impianti e macchinari, Progetto Codice ULS 002 Sensoristica interconnessa per la sicurezza, prof. R. Baldoni (up to July 2011)

- Università La Sapienza and Ministero della salute, € 140.000, Accordo di collaborazione per la realizzazione del nuovo portale internet del Ministero, T. Catarci (up to 29/12/2010)

- Ministero dello Sviluppo Economico, Industria 2015, € 83.830, Progetto di innovazione industriale mobilità sostenibile, programma "Context Aware Mobility Platform (CAMP)", L. Iocchi (up to 31/12/2011)

- ISTAT, € 30.000, Studio/ricerca sul tema: "Applicazioni prototipali idonee a risolvere problemi di programmazione lineare in procedure di controllo, correzione e validazione di dati censuari", A. Sassano (up to 31/12/2010)

- Dipartimento Risorse Tecnologiche Servizi Delegati – Statistica del Comune di Roma, € 20.000, Studio/ricerca sul tema "Nuovo sistema informativo di gestione del territorio", B. Ciciani (up to 30/04/10)

- ISPRA – Istituto per la protezione e la ricerca ambientale, Dipartimento tutela acque interne e marine, € 25.000, Studio/ricerca sul tema "Tecnologie di accesso alle informazioni sulla tutela delle acque", M. Schaerf (up to 28/03/11)

- ISTAT – Istituto Nazionale di Statistica, 40.000, Studio/ricerca sul tema "Realizzazione di nuove metodologie basate sull'utilizzo di tecnologie di Ricerca Operativa per il controllo a livello micro-amacro dei dati, implementazione delle stesse", G. Di Pillo (up to 11/10/12)

- ENEA – Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, € 19.000, Studio/ricerca sul tema "Studio per l'implementazione del sistema di controllo della densità del plasma del Tokamak FTU per il C.R. ENEA di Frascati", S. Monaco (up to 08/05/11)

Contracts with Companies

- Act Solutions Srl, € 30.000, Studio/ricerca sul tema "Reti Neurali" con particolare riferimento agli algoritmi di identificazione automatica di parametri e struttura delle reti, G. Di Pillo (up to 19/01/2010)

- Space Software Italia Spa, € 47.400, Studio/ricerca sul tema SAMAS "Sottosistema di cooperazione", D. Nardi (up to 25/01/2010)

- Telecom Italia Spa, € 30.000, Studio/ricerca sul tema "Tecnologie peer to peer applicate alla rete di un operatore telefonico", R. Baldoni (up to 31/01/2010)

- Act Solutions Srl, € 30.000, Studio/ricerca sul tema "Ottimizzazione – simulazione e previsione con con particolare riferimento allo sviluppo e sperimentazione di metodi da utilizzare in applicazioni nell'ambito delle attività di ACT", G. Di Pillo (up to 28/01/2011)

- Space Software Italia Spa, € 126.700, Studio/ricerca sul tema "SAMAS – Sottosistema di Cooperazione", D. Nardi (up to 27/02/11)

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

- SPIN Applicazioni Magnetiche srl, € 16.500, Studio/ricerca sul tema "Programmi di Ottimizzazione per la Progettazione in Ambito Elettromeccanico", G. Di Pillo (up to 12/12/11)

- DUEL SPA, Studio/ricerca sul tema "Sistema avanzato per pubblicità virtuale tridimensionale", D. Nardi, L. Carlucci Aiello and L. Iocchi (up to 12/06/12)

Research Agreements (Convenzioni)

- Consorzio Interuniversitario Nazionale per l'Informatica (CINI) (up to 24/04/2011)

- Fondazione Ugo Bordoni (FUB) (up to 07/03/2011)

- Nous Informatica srl (up to 10/07/2011)

- Istituto Tecnico Vallauri, Società Open Informatica srl, Società Master Brain di Stefano Fava (up to 03/02/2011)

- Fondazione S. Lucia (up to 14/11/2013)

- Agenzia delle Entrate (up to 11/10/2011)

- CRAT Consorzio per la ricerca nell'automatica e nelle telecomunicazioni (up to 31/03/2012)

- CISIT S.c.r.l. (up to 12/12/2013)

2.6 Seminars and Workshops

Many scientists are invited to deliver seminars at DIS each year. Below is a list of seminars for the year 2010, in chronological order. Also the Workshops organized at DIS are reported, with the exception of the project meetings.

- January 22, Alessandro Amato, Istituto Nazionale di Geofisica e Vulcanologia, *Terremoti in Italia: cosa sappiamo e cosa vorremmo sapere*

- January 25, Fernando Matia, Universidad Politecnica de Madrid, *Activities of the intelligent control group at Universidad Politécnica de Madrid*

- February 17, Christoph Buchheim, TU Dortmund, *A fast branch-and-bound algorithm for convex mixed-integer optimization*

- February 22, Robert Fairlie, University of California Santa Cruz, *The effects of home computers on educational outcomes: evidence from a field experiment with community college students*

- February 24, Zakaria Maiga and Ireneusz Smigiel, Parasoft, *Prevenire è meglio che curare. L'utilizzo dei tool automatici Parasoft*

- February 25, Carlo Batini, University of Milano Bicocca, *Data architectures: technological, organizational and economic issues*

- February 26, ACT Solutions, *Introduction to Simio, a simulation software for discrete event simulation based on intelligent objects*

- March 4, Amos Fiat, Tel-Aviv University, *Private coresets, data sanitization, and geometry*

- April 16, Francesco Rogo, Finmeccanica, *Software development in finmeccanica: safety critical software for aerospace & defense applications*

- April 22, Slawomir Grzonka, University of Freibur, *A fully autonomous indoor quadrotor*

- April 23, Ferdinando Caputo, EMC Computer Systems Italia, *Journey to the private cloud*

- May 7, Alessio Di Benedetto, EMC Computer Systems Italia, *Business continuity & disaster recovery: technology and processes*

- May 11, Alexander Strekalovskiy, The Siberian Branch of Russian Academy of Sciences, *Elements of non-convex optimization*

- May 13, Vincenzo Bonifaci, Max-Planck Institute for Computer Science, *Scheduling recurrent real-time task systems*

- May 14, Paolo Trevisan, Accenture, *Next generation IT infrastructure: dai data center di nuova generazione ai servizi in the cloud*

- May 21, Aris Anagnostopoulos, University of Rome La Sapienza, *Understanding users behavior in social networks*

- May 21, Franco Martino, EMC Computer Systems Italia, *Beyond green: energy efficient IT*

- May 21, Jacqueline Morgan, Università di Napoli Federico II, *Altruistic behavior and Nash equilibria*

- May 25-29, *International Working Conference on Advanced Visual Interfaces*, organized by Sapienza Università di Roma

- May 27, Vito Trianni, Institute of Cognitive Sciences and Technologies (CNR), *Evolution, self-organisation and swarm robotics*

- May 28, Luca Crocioni, Andrea Migliore, Alessandro Moriondo and Giovanni Caliendo, Hewlett-Packard Italiana, *Data center e service availability: dal cluster alle soluzioni disaster recovery/disaster tolerant*

- May 28, Marcello La Rosa, Queensland University of Technology, *Managing variability in process-aware information systems*

- June 10, Giorgio Grisetti, Albert Ludwigs Universitaet Freiburg, *Graph-based SLAM using stochastic gradient descent and hierarchical least-squares*

- June 11, Aris Gionis, Yahoo! Research, *The community-search problem and how to plan a successful cocktail party*

- June 14, Vladimir Kucera, Czech Technical University in Prague, *Polynomial equation approach to linear control system design*

- June 17, Verena Kantere, École Polytechnique Fédérale de Lausanne, *Online data services in the cloud*

- July 1, Corentin Travers, Laboratoire d'Informatique de Paris 6, *Weak coordination tasks in asynchronous distributed systems*

- July 21, Sebastian Sardina, RMIT University in Melbourne, *Planning via petri-net unfolding: a novel technique for parallel planning*

- July 23, Stefano Soatto, University of California Los Angeles, *Data to information to cognition: the lesson from shannon to gibson, and the first steps towards a theory of visual information*

- July 30, Jim Little, University of British Columbia, *Actively using vision and context for home robotics*

- September 13, Hiroaki Yamaguchi, Aoyama Gakuin University, *Control of a new type of undulatory robotic locomotor: a trident steering walker*

- September 14, Moe Thandar Wynn, Queensland University of Technology, *Cost-aware business process management*

- September 16, Paolo Romano, INESC-ID, *Boosting data replication in distributed transactional memories*

- October 28, Satoshi Tadokoro, Tohoku University, *Robotic systems for urban search and rescue*

- November 17, Esteban Feuerstein University of Buenos Aires, *Performance evaluation of some architectural and algorithmic ideas for distributed search*

- December 15, Matei Mancas, University of Mons, *Overview of the research at the IT department of the University of Mons, Belgium*

- December 17, Alexander Kleiner, Albert Ludwigs Universitaet, Freiburg, *Hierarchical visibility for guaranteed search in large-scale outdoor terrain*

- December 17, Bernhard Nebel, Albert Ludwigs Universitaet, Freiburg, *Coming up with good excuses: what to do when no plan can be found*

In addition, DIS organizes a series of seminars in cooperation with the Department of Computer Science (DI). Below is the list of the seminars of the series.

- January 25 at DIS, Fabrizio Frati, Roma Tre University, *Testing planarity of partially embedded graphs*

- February 8 at DIS, Stefano Leonardi, University of Rome La Sapienza, *Combinatorial auctions with budgets*

- February 22 at DIS, Fabrizio Grandoni, University of Rome "Tor Vergata", *An improved lp-based approximation for steiner tree*

- March 8 at DIS, Marek Cygan, University of Warsaw, *Kernelization hardness*

- March 29 at DIS, Fabrizio Silvestri, Consiglio Nazionale delle Ricerche, *Diversifying search results using query logs*

- April 16 at DI, Andrea Clementi, University of Rome "Tor Vergata", *Modeling mobility: a discrete revolution*

- May 17 at DI, Jerrold R. Griggs, University of South Carolina Columbia, *Venn diagrams, necklaces, and chain decompositions of posets*

- May 31 at DIS, Paul Wollan, University of Rome La Sapienza, *A shorter proof for the disjoint paths algorithm*

- October 11 at DI, Francesco Silvestri, University of Padova, *Obliviousness in the parallel settings*

- November 15 at DI, Alexandre Stauffer, University of Berkeley, *Detection and percolation in mobile geometric graphs*

2.7   Awards and Individual Grants

- Luigia Carlucci Aiello, Premio Mimosa d'oro 2010, April

- Aris Anagnostopoulos, Marie Curie Incoming International Fellowship, June

- Luca Becchetti, Ilaria Bordino and Stefano Leonardi, Best Paper Award at the 1st International Workshop on Novel Data Stream Pattern Mining Techniques, July

- Vincenzo Bonifaci and Alberto Marchetti Spaccamela, Best Paper Award at the 18th Annual European Symposium on Algorithms (ESA), September

- Antonio Franchi, 2010 Young Author Best Paper Award of the IEEE Robotics and Automation Society - Italian Chapter, September

- Roberto Baldoni, IBM Faculty Award 2010, September

- Giuseppe De Giacomo, IBM Open Collaborative Faculty Award 2010, October

- Piotr Sankowski, ERC Starting Independent Researcher Grant, October

- Laura Astolfi, Sapienza Ricerca Award for "under-40" researchers, November

- Floriana Di Pinto, Sapienza Master Thesis Award, November

- Fabio D'Andreagiovanni, Informs Best Dissertation Award (Telecommunications track), December

3 Research

3.1 Algorithm Design and Engineering

Research lines:

- Principles of Design and Analysis of Algorithms

- Experimental Algorithmics

- External Memory and Streaming Algorithms for Massive Data Processing

- Incremental Algorithms and Dynamic Data Structures

- Approximation and On-line Algorithms

- Algorithmic Game Theory

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

PhD Students: Donatella Firmani.

Post Docs: Aris Anagnostopoulos, Vincenzo Bonifaci, Luigi Laura, Andrea Ribichini, Piotr Sankowski.

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

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

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

- External Memory and Streaming Algorithms for Massive Data Processing: external-memory and streaming algorithms for very large graph problems;

- Incremental Algorithms and Dynamic Data Structures: incremental algorithms for path problems in graphs;

- Approximation and On-line Algorithms: scheduling algorithms, algorithms for metabolic networks, vehicle routing, approximation algorithms for rent-or-buy network design problems, on-line algorithms for stochastic optimization problems such as Steiner tree and set cover under several models;

- Algorithmic Game Theory: quality of strong equilibria in network formation games under restricted communication model.

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

- External Memory and Streaming Algorithms for Massive Data Processing: external-memory and streaming algorithms for problems arising in the dynamic analysis of large software systems and networks. Among other goals, we plan to investigate novel approaches to performance profiling and optimization based on provably efficient streaming techniques;

- Incremental Algorithms and Dynamic Data Structures: we will study efficient incremental change propagation techniques for constraint-based systems on multi-core platforms;

- Approximation and On-line Algorithms: we aim at investigating the complexity and the approximability of combinatorial resource allocation problems, with a focus on problems arising from the scheduling of recurrent tasks in real-time systems. In particular, we aim at the design and analysis of efficient tests of feasibility for the scheduling of tasks on multiprocessor platforms. We will push further the study of on-line algorithms for stochastic optimization problems. We'll also consider the simultaneous approximation on several objective functions and on network instances.

Projects:

- *AlgoDEEP: Algorithmic Challenges for Data-intensive Processing on Emerging Computing Platforms* - March 2010, September 2012 - PRIN MIUR.

- *MAINSTREAM: Algorithms for massive information structures and data streams* - May 2007, February 2009 - PRIN MIUR.

- *AEOLUS: Algorithmic principles for building overlay computers* - December 2005, December 2010 - EU FP6 FET.

- *FRONTS: Foundations of Adaptive Networked Societies of Tiny Artefacts* - March 2008, March 2012 - EU FP7 FET.

- *SIMBIOSI: INRIA associated team* - January 2009, January 2011 - INRIA.

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[4] Baruah S.K., Bonifaci V., Marchetti-Spaccamela A. and Stiller S., Improved multiprocessor global schedulability analysis. *Real-Time Systems*, 46(1), pp. 3–24, 2010.

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[10] Demetrescu C. and Italiano G.F., La ricerca della via più breve. Chapter L'informatica invisibile, a cura di G. Ausiello, R. Petreschi, Mondadori Università, Sapienza Università di Roma, 2010.

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[11] Ausiello G. and Petreschi R. (eds)., L'informatica invisibile. Mondadori Università, Sapienza Università di Roma, 2010.

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[12] Italiano G.F., Laura L. and Naldi M., Traffic-based network clustering. *Proceedings of the 6th International Wireless Communications and Mobile Computing Conference, IWCMC 2010,* Caen, France, June 28 - July 2, pp. 321–325, 2010.

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[14] Anagnostopoulos A., Grandoni F., Leonardi S. and Sankowski P., Online Network Design with Outliers. *Proceedings of the 37th International Colloquium on Automata, Languages and Programming (ICALP 2010)*, Springer, pp. 114–126, 2010.

[15] Anagnostopoulos A., Dombry C., Guillotin-Plantard G., Kontoyiannis I. and Upfal E., Stochastic analysis of the k-server problem on the circle. *Proceedings of the 21st International Meeting on Probabilistic, Combinatorial and Asymptotic Methods for the Analysis of Algorithms (AofA 2010)*, DMTCS, pp. 21–34, 2010.

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[17] Cygan M., Kowalik L., Mucha M., Pilipczuk M. and Sankowski P., Fast Approximation in Subspaces by Doubling Metric Decomposition. *Proceedings of the 18th Annual European Symposium on Algorithms (ESA 2010)*, pp. 72–83, 2010.

[18] Bonifaci V., Chan H.L., Marchetti-Spaccamela A. and Megow N., Algorithms and Complexity for Periodic Real-Time Scheduling. *Proceedings of the 21st Annual ACM-SIAM Symposium on Discrete Algorithms, SODA 2010*, Austin, Texas, USA, January 17-19, pp. 1350–1359, 2010.

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[25] Ausiello G., Firmani D. and Laura L., Real Time Monitoring of Undirected Networks: Articulation points, Bridges, and Connected and Biconnected Components. Expected To appear in *Networks*, 2011.

[26] Alimonti P., Feuerstein E., Laura L. and Nanni U.. Linear Time Analysis of Properties of Conflict-Free and General Petri Nets. *Theoretical Computer Science*, 412(4-5), pp. 320–338, 2011.

[27] Frandsen G.S. and Sankowski P., Dynamic normal forms and dynamic characteristic polynomial. *Theoretical Computer Science*, 412(16), pp. 1470–1483, 2011.

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3.2 Artificial Intelligence and Knowledge Representation

Research lines:

- Description Logics

- Reasoning about Actions

- Semantic Web

- Logics for AI

- Cognitive Robotics

Members: Luigia Carlucci Aiello (leader), Giuseppe De Giacomo, Maurizio Lenzerini, Paolo Liberatore, Domenico Lembo, Daniele Nardi, Fiora Pirri, Riccardo Rosati, Marco Schaerf.

PhD Students: Riccardo De Masellis, Paolo Felli, Mario Gianni, Matteo Leonetti, Gabriele Randelli, Domenico Fabio Savo.

Post Docs: Marco Ruzzi, Vittorio Amos Ziparo.

Research in Artificial Intelligence at DIS 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 DIS on DL has a long tradition, and focuses on many relevant aspects, including algorithms for automated reasoning, trade-off between expressive power and computational complexity of reasoning, query answering in DL knowledge bases, adding both monotonic and non-monotonic rules to DL. In the future, the work on DL will both continue along the above mentioned lines and focus on dynamic aspects, such as update and revision of DL knowledge bases, and reasoning about programs expressed on such knowledge bases.

Reasoning about Actions concerns the theory and the implementation of agents that reason, act and perceive in changing, incompletely known, and unpredictable environments. Such agents must have higher level cognitive functions that involve reasoning, for example, about goals, actions, when to perceive and what to look for, the cognitive states of other agents, time, collaborative task execution, etc. Our research on Reasoning about Actions focuses on several aspects, including: foundations of theory of actions; various forms of planning for sophisticated dynamic properties, e.g., expressed in LTL;

high-level agent programs, like *ConGolog* based on the Situation Calculus; agent behavior synthesis and composition. This research is also related with, and applied to, other areas, such as cognitive robotics, multi-agent/multi-robot systems, software service modeling, execution and composition, high-level programs over ontologies and data sources.

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

Another research strand is focused on belief revision (how to revise knowledge when new information is given), default logic (how to draw inference in case precise information is lacking), and automated planning.

Finally, one research stream specifically addresses action representation and world modeling in intelligent robots, also in connection with the work in Multi-Agent and Multi-Robot Systems. The goal is to bridge the gap between the theoretical work in knowledge representation and reasoning and the design of intelligent robotic systems.

Projects:

- Space Software Italia Spa, € 47.400, *Studio/Ricerca sul tema SAMAS "Sottosistema di cooperazione"*, D. Nardi (up to 25/01/2010).

- *Networked mixed human robot teams for applications in emergency scenarios*, € 13.500, Sapienza Finanziamento Progetti di Ricerca Anno 2010.

- FP7-CP, € 729.424, *NIFTi: Natural human-robot cooperation in dynamic environments*, F. Pirri (up to 31/12/2013)

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[17] Calvanese D., De Giacomo G., Lenzerini M. and Rosati R., View-based Query Answering in Description Logics: Semantics and Complexity. Expected To appear in *Journal of Computer and System Sciences*, 2011.

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3.3 Combinatorial Optimization

Research lines:

- Polyhedral Combinatorics

- Graph theory and Optimization

- Telecommunication Network Design

- Scheduling and Job-shop Scheduling

- Computational biology and polymer sequencing problems

- Satisfaction of logic formula

- Finance

- Data mining and universe selection problems

- Machine learning

Members: Carlo Mannino, Antonio Sassano (leader).

PhD Students: Carla Michini.

Post Docs: Renato Bruni, Silvia Canale, Fabio D'Andreagiovanni, Sara Mattia.

The activity of the Combinatorial Optimization Group at DIS dates back to the early '90s and has been focused both on the theoretical properties of combinatorial structures and the use of sophisticated algorithmic tools to solve real-life problems.

Main research topics: 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, data mining and sequence analysis in polymers reconstruction, algorithms for matching. In the last 10 years the group has developed methods and algorithms aimed at the optimal design of wireless 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. Finally, a long standing and fruitful collaboration with the Italian National Statistic Office has been carried out in the field of data mining.

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; algorithms for weighted matching problems; polyhedral properties of interval and staircase matrices; optimization techniques for boosting problems in machine learning; purely combinatorial approaches to wireless network design; traffic control and optimization in railway networks.

Projects:

- *Metodi di ottimizzazione su larga scala nelle telecomunicazioni*, progetto PRIN 2008, n. 2008LLYXFS.

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3.4 Computer Networks and Pervasive Systems

Research lines:

- Wireless and Sensor Networks

- Networks of Resource Constrained Devices

- Streaming Applications over Wireless

- Network Coding

- Self-* Protocols and Systems

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

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

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

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

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

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

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

Projects:

- *Progetto FIRB Italia Israele, Sapienza-Technion Haifa* - July 2007, July 2009 - MIUR FIRB.

- *PANORAMA: Coordinated Action on Pervasive Adaptation* - February 2008, January 2011 - EU FP7 Coordinated action.

- *FRONTS: Foundations of Adaptive Networked Societies of Tiny Artefacts* - February 2008m, January 2011 - EU FP7 IP.

- *AEOLUS: Algorithmic principles for building overlay computers* - September 2006, February 2010 - EU FP6.

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3.5   Computer Vision, Computer Graphics, and Perception

Research lines:

- Augmented Reality and Computer Animated Virtualization

- Human Motion Analysis, Gesture Recognition, Physics based methods

- Attention, Recognition and Scene Understanding

- Auditory Perception

- Geometric Modeling and Multi-view Geometry

- Pattern Recognition

- Modeling Uncertainty in Knowledge Representation

- Multimodal Human Robot Interaction

Members: Alberto De Santis, Daniela Iacoviello, Luca Iocchi, Fiora Pirri (leader), Marco Schaerf.

PhD Students: Andrea Carbone, Mario Gianni, Letizia Marchegiani, Alessio Pascucci, Matia Pizzoli, Simone Sagratella.

Post Docs: Panagiotis Papadakis.

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

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

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

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

Projects:

- *NIFTi - Natural human-robot cooperation in dynamic environments* - 2010, 2014 - EU FP7 IP.

- *SARFIRE - Spaceborn SAR imagery and environmental data fusion for the dynamical evaluation of land regions susceptibility to fire* - 2010, 2012 - ASI Cosmo Sky Med.

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3.6 Continuous Optimization

Research lines:

- Nonlinear Programming

- Derivative Free Methods

- Global Optimization

- Semidefinite Programming

- Variational Inequalities

- Game Engineering

- Neural Networks and Support Vector Machines

- Engineering Design Optimization

- Resource allocation in communication networks

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

PhD Students: Stefania De Angelis, Marianna De Santis, Andrea Ianni, Lorenzo Lampariello, Vittorio La Torre, Mauro Piacentini, Simone Sagratella, Serena Teobaldo.

Post Docs: Francesco Rinaldi.

Research in continuous optimization has been active DIS 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, decomposition techniques and preconditioning methods for the solution of difficult large-scale nonlinear optimization problems and nonlinear equations.

- Preconditioning Newton-Krylov methods in nonconvex large scale optimization, which is an important tool for efficiently solving large difficult problems.

- Derivative-free algorithms, of special interest in many engineering applications where even the calculation of function values is problematic and very time-consuming.

- Global optimization, which is an essential tool for solving problems where local non-global solutions may be meaningless.

- Semidefinite programming, that plays an essential role in the development of efficient algorithms for solving relaxations of non-convex and integer problems.

- Finite dimensional variational inequalities and complementarity problems, which often arise in modelling a wide array of real-world problems where competition is involved.

- Generalized Nash equilibrium problems, which are emerging as a winning way of looking at several classical and non-classical engineering problems.

- Training methods for neural networks and support vector machines, for constructing surrogate models of complex systems from sparse data through learning techniques.

- Mixed Integer Nonlinear Programming (MINLP) problems that combine combinatorial aspects with nonlinearities.

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

- Design of electro-mechanic devices.

- Development of electromagnetic diagnostic equipments.

- Power allocation in TLC.

- Shape optimization in ship design.

- Multiobjective optimization of nanoelectronic devices.

- Sales forecasting in retail stores.

Projects:

- *Nonlinear Optimization, Variational Inequalities and Equilibrium Problems* - September 2008, September 2010 - MIUR PRIN.

- *MODERN: MOdeling and Design of Reliable Nanoelectronics devices* - March 2009, February 2012 - ENIAC European Nanoelectronics Initiative Advisory Council.

- *MANON: Methods for Advanced multi-objective optimization of complex NANoscale circuits* - April 2010, March 2012 - UE FP7/PEOPLE.

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3.7   Data Management and Service-Oriented Computing

Research lines:

- Data Integration and Exchange

- Ontology Based Information Systems

- Data Warehousing, Data Quality and Data Cleaning

- Digital Records Management and Preservation

- Process and Workflow Management

- Service Modeling

- Service Synthesis and Composition

Members: Tiziana Catarci, Giuseppe De Giacomo, Domenico Lembo, Maurizio Lenzerini (leader), Massimo Mecella, Riccardo Rosati, Silvio Salza.

PhD Students: Riccardo De Masellis, Claudio Di Ciccio, Floriana Di Pinto, Paolo Felli, Francesco Leotta, Andrea Marrella, Alessandro Russo.

Post Docs: Massimiliano de Leoni, Fabio Patrizi, Antonella Poggi.

Our interest in Data Management dates back to the '80s, when the main research topics were conceptual modeling and schema integration, now evolved into Information Integration and Data Exchange. Information integration is the problem of combining the data residing at different heterogeneous sources, and providing a virtual unified view of these data, called global schema, which can be queried by the users. Data Exchange focuses instead on the problem of materializing the global schema according to the data retrieved from the sources. Both (virtual) data integration and data exchange have been recently studied in the context of a peer-to-peer (P2P) data management, where autonomous systems (peers) export data in terms of their own data schema, and import data from other peers to which their are connected through semantic mappings. Other Data Management topics related to Information Integration are also investigated, including Ontology-based Information Systems, View-based Query Processing, Data Quality, Data Cleaning, Record Matching and Instance Reconciliation, and Mobile Data Access.

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

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

1. posing the semantics of the application domain at the center of the scene,

2. combining the management of data with the management of the processes and services using such data in the organization, and

3. 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.

Projects:

- *ACSI - Artifact-Centric Service Interoperation*, June 2010 - May 2013 (EU FP7).

- *GreenerBuildings - An ubiquitous embedded systems framework for energy-aware buildings using activity and context knowledge*, September 2010 - August 2013 (EU FP7).

- *SM4All - Smart homes for all*, September 2008 - August 2011 (EU FP7).

- *COLLECTIVE - Emerging communities for collective innovation: ICT Operational tool and supporting methodologies for SME Associations* January 2010 - December 2012 (EU FP7).

- Progetto finanziato da IBM: *Sviluppo di una ontologia in ambito bancario*, June 2010 - May 2012.

- Progetto finanziato dalla Regione Lazio: *Integrazione semantica di dati e servizi per le aziende in rete*.

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3.8 Distributed Systems

Research lines:

- Smart Environments

- Overlay-based Systems

- Resource Sharing Systems

- Event-based Systems

- Distributed Systems Interoperability

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

PhD Students: Leonardo Aniello, Adriano Cerocchi, Luca Montanari, Marco Platania, Hani Qusa.

Post Docs: Silvia Bonomi, Giorgia Lodi.

The Distributed Systems group has developed, in the last ten years, a solid worldwide reputation in the context of theory and practice of distributed, pervasive and p2p computing, middleware platforms, and information systems infrastructures. On these topics, the group has created strong relationships with the most influential research groups in the world. In the last ten years the group has developed several theories and practical experiences that are fully referenced by the research community, including checkpointing,

causal ordering theory, distributed replication systems, interceptors, group toolkits, and publish subscribe systems.

The distributed systems group has participated and successfully coordinated several important EU projects in the context of e-government, security and dependability of large scale systems, and protection of the financial infrastructure. It has developed remarkable connections with the major Italian ICT industries and Public Administrations for creating innovative solutions and prototypes transferring the latest results from research area into practice. Our activities are centered in two laboratories: MidLab and the Joint-Lab of Security Research.

MidLab is focussed in research, its primary goal is to support leading-edge research and development on middleware bridging the gap between the latest research results and the current technologies. In particular main MIDLAB targets are the study, the design and analysis of novel middleware platforms able to increase the robustness of information exchanging with respect to reliability, consistency, predictability and security.

The Joint-Lab on Security research, focused on innovation, has the mission to create a critical mass of system researchers at Sapienza Università di Roma with expertise in the development of secure and reliable systems for such domains. The team includes experts in HW design, networking, system and software security, applications and services development.

In addition to the further development of on-going research projects, our future activities will include three important new branches of research: (*i*) creating solid foundational theory on dynamic aspects of distributed Systems, (*ii*) methodologies and techniques for massive distributed event processing (*iii*) middleware for smart spaces (including energy savings in public buildings and intelligent houses). All these topics are indeed rapidly evolving, and the advent of new classes of applications and technologies, such as federation of clouds, airborne networks, smart environments, broad area supercomputing, and distributed resource sharing services, is boosting their importance. The theoretical effort is also accompanied by several practical projects in the area of smart environments, namely *SOFIA*, *SM4All* and *Greener Buildings*, and in collaborative security, namely *CoMiFin*, that motivate the foundational research.

The Distributed System group will participate to the Shanghai 2010 with two prototypes developed jointly with the MultiAgent and Multi Robot systems group and the Data Management and Service-Oriented Computing. The group is also organizer of DISC 2011 and of the Master in Interoperability of complex systems for Organizations and Public Administrations.

Projects:

- *SM4All, Middleware Platform for Pervasive and Immersive Environments For-ALL* - September 2008, August 2011 - EU Strep.

- *SOFIA, Smart Objects For Intelligent Applications* - January 2009, December 2011 - EU IP ARTEMIS.

- *CoMiFin, Communication Middleware for monitoring financial critical infrastructure* (Project managed by CINI - Consorzio Interuniversitario Nazionale per l'Informatica) - September 2009, March 2011 - EU STREP .

- *DOTS-LCCI, Reliable Middleware systems for Critical Infrastructures based on off-the-shelf components* - March 2010, March 2012 - PRIN MIUR.

- *BLEND, Blending Technologies for Ubiquitous Real-Time Data Access* - June 2010, June 2012 - EUREKA Project.

- *GreenerBuilding, An Ubiquitous Embedded Systems Framework for Energy-aware Buildings using Activity and Context knowledge* - September 2010, August 2013 - EU Strep.

- *Domus Nova, an advanced domotic environment for monitoring the health of elderly and/or risky people* - September 2010, August 2013 - Regional project.

- *Iniziativa Software (ii) – Identification of critical pattern for failure detection in complex distributed systems* (Project managed by CINI - Consorzio Interuniversitario Nazionale per l'Informatica) - January 2010, December 2012 - CINI-FINMECCANICA.

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[8] Baldoni R., Bonomi S., Lodi G. and Querzoni L., Data Dissemination supporting collaborative complex event processing: characteristics and open issues. *Workshop on Data Distribution for Large-Scale Complex Critical Infrastructures*, 2010.

[9] Baldoni R., Bonomi S. and Raynal M., Value-based sequential consistency for set objects in dynamic distributed systems. *Proceedings of the 16th international Euro-Par conference on Parallel processing*, 2010.

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3.9   High Performance and Dependable Computing Systems

Research lines:

- Parallel and Distributed Computing Platforms

- Multi-tier Architectures

- Transactional Systems

- Virtualization and Cloud Computing

- Performability Models

Members: Bruno Ciciani, Francesco Quaglia.

PhD Students: Pierangelo Di Sanzo, Roberto Palmieri, Alessandro Pellegrini, Sebastiano Peluso, Diego Rughetti, Roberto Vitali.

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

- the definition of frameworks and protocols for dependability in large scale infrastructures, with particular attention to application contexts entailing manipulation of data within (atomic) distributed transactions;

- the design and implementation of high performance computing platforms, with particular interest to discrete event simulation platforms conforming to both proprietary and standardized protocol stacks;

- the definition and validation of accurate performance and dependability models for components/sub-systems forming the core of the aforementioned computing environments.

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

Several research challenges can be easily envisaged along the paths of Quality-of-Service (QoS) oriented design of systems, as well as the design of autonomic systems embedding self* properties aimed at ensuring/guaranteeing/achieving pre-determined performance and/or dependability levels. The container hosting and framing these challenges will include both traditional system organizations and innovative computing environments relying on systematic use of infrastructure virtualization approaches, such as cloud computing. Further, we plan to target innovative programming models and paradigms, such as concurrent programming based (a) on updates relying on the (software) transactional memory paradigm, and (b) on transparent and automatic techniques supporting reverse computing schemes as a mean for maintaining causal consistency. The latter will complement the wide set of results already achieved in the context of transparent and efficient (volatile) log/restore schemes in support of both fault-tolerance and optimistic synchronization.

Projects:

- *ARISTOS: Autonomic ReplicatIon of Software TransactiOnal memorieS* - January 2010, December 2012 - PTDC Portugal/Italy Bilateral Project.

- *INSYEME: INtegrates SYstem for EMErgencies* - November 2007, October 2010 - MIUR FIRB.

- *WEBMINDS: Wide ScalE Broadband MIddleware for Network Distributed Services* - November 2002, October 2006 - MIUR FIRB.

- *PERF: Performance Evaluation of Complex Systems: Techniques, Methodologies and Tools* - November 2002, October 2006 - MIUR FIRB.

- *Cloud-TM: A Novel Programming Paradigm for the Cloud* - June 2010, May 2013 - FP7 STREP

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

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3.10   Human-Computer Interaction

Research lines:

- User Interfaces

- Usability Engineering and Accessibility

- Information Visualization

- Automated Personalization and Adaptation in Web-based Learning

- Web-based Social Collaborative Learning

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

PhD Students: Claudio Di Ciccio, Andrea Marrella, Shah Rukh Humayoun, Alessandro Russo.

Post Docs: Massimiliano de Leoni

Human-Computer interaction (HCI) is the study of the interaction between people (users) and computers. Such an interaction traditionally occurs at the user interface, but its effectiveness is strongly related with the design of the entire interactive system, referring in particular to the way in which it supports the user in achieving her/his goals and executing her/his tasks. Indeed, an important facet of HCI is the securing of the interactive system usability. The research group started working on HCI topics during the late '80s, while developing a visual interface for databases. This pioneering work can be regarded as one of the first and most significant examples of deep analysis and formalization of the interaction between the user and the database, which takes into consideration both usability issues and language related aspects.

Following these lines, the group developed another relevant research topic, namely the definition of adequate visual representations of the databases, in terms of both schema and instances. Note that using a consistent visual representation to depict the information of interest is crucial in order for the user to correctly grasp the database information content. Related with visual representation is information visualization, i.e. the use of computer-based, visual, interactive representations of information with the purpose of making sense out of data, acquire knowledge, discover new information, and effectively present the result.

In the last years we focused on clutter reduction for information visualization analyzing the visual issues associated with the use of density maps focusing on the correct assignment of visual variable values to a data domain, taking into account its frequency distributions. Other HCI topics are also investigated, including the study of specific usability, accessibility, and adaptivity methodological aspects, the interaction with different realms, e.g. digital libraries, cultural artifacts, mobile and ubiquitous systems, e-learning environments.

Designing interactive systems that could be effectively, efficiently and with satisfaction used by people exhibiting different characteristics, needs, preferences and abilities is getting more and more important in Information Technology research and development, as it is clearly demonstrated by the growing importance of the user role in research projects as well as in public administration developments, by the introduction in several Laws of precise usability and accessibility requirements for governmental information systems, by the continuous increase of funding for HCI-related research at EU and international level.

We have been among the pioneers of the research in this field in Europe, in particular in the effort of giving formal basis to the definition of interaction while considering human-related, perceptual aspects. We are still continuing in this direction, in particular

by working on a machine-interpretable and machine-learnable model of user task that will be the basis for a novel task-oriented interaction model, to be tested in personal information environments. Furthermore, innovative interaction styles, e.g. brain-computer interfaces, ubiquitous and sensor-based environments, extreme visualizations, are under study, as well as novel design methodologies, advancing traditional user-centered design both with the injection of agile concepts and directly encompassing accessibility aspects.

Projects:

- *Collaboration and Decision Making in Engineering* - October 2010, September 2014 - EU FP7

- *PROMISE – PARTECIPATIVE Research Laboratory for Multimedia and Multilingual Information Systems Evaluation* - September 2010, August 2010 - EU FP7

- *BrIndiSys – Brain-computer interface devices to support individual autonomy in locked-in individuals* - October 2010, September 2013 - AriSLA Bando 2009

- *understandIT* - October 2010, September 2012 - Leonardo Da Vinci programme

- *SM4All - Smart homes for all* - September 2008, August 2011 - EU FP7.

- *WORKPAD - An Adaptive Peer-to-Peer Software Infrastructure for Supporting Collaborative Work of Human Operators in Emergency/Disaster Scenarios* - September 2006, August 2009 - EU FP6.

- *DELOS - Network of Excellence on Digital Libraries* - January 2004, December 2008 - EU FP6.

- *VisMaster - Coordination Action on Visual Analytics* - August 2008, July 2010 - EU FP7.

- *QUIS - QUality, Interoperability and Standards in e-learning* - February 2005, April 2007 - EU FP6.

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3.11 Hybrid Control Systems

Research lines:

- Nonlinear and Sampled Data Systems

- Discrete-time Systems

- Emergent and Innovative Control Strategies

- Switching Control Systems

- Sensors and Measurements

- Sensor Networks

Members: Stefano Battilotti, Luca Benvenuti, Claudia Califano, Paolo Di Giamberardino, Salvatore Monaco (leader).

PhD Students: Andrea Abelli, Antonio D'Angelo, Enrico Gentili, Marco Paoletti, Daniele Pucci, Fernando Tiefensee.

The hybrid nature of most real control systems strongly demands for the development of a theory for modelling their inherent complexity. From the systems and control theory point of view, the complexity is related to the use of devices which have a different nature, and interact through computational procedures. In particular the research carried out at DIS concerns:

- the proposition of ad hoc methodologies for dealing with sampled data signals as well as representations and design methodologies for discrete time systems - *Nonlinear Sampled-Data and Discrete-Time Systems*;

- the investigation on new paradigms of representing the knowledge and designing the control strategies – *Emergent and Innovative Control Strategies*;

- the study of problems related to the presence of quantization and switching, due to the presence of continuous od discrete-time, sampled or quantized variables) - *Digital and Switching Control*;

- the analysis and design of sensors networks, for solving complex control problems where measurement and data processing of many devices must be handled - *Sensors, Measurements and Sensor Networks*.

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

Passivity in discrete-time and under sampling - Robust control strategies based on passivity properties or more in general dissipativity concepts are widely investigated from theory to practice in terms of Lyapunov design or H_∞ control as many other efficient approaches for capturing and respecting the physical structure of the process. Specialized studies are needed in discrete. How to define dissipativity in discrete time and how do dissipation inequalities evolve under sampling are challenging problems as they directly affects the related design methods.

Observer theory - In recent works the introduction of output transformations and time scaling transformations has lead to a new trend in the observer design. The use of geometric tools allows to set, in the discrete-time context, constructive necessary and sufficient conditions for the existence of such canonical forms. State estimation of single-output nonlinear systems with semi-Markov jump, a still open problem, will be investigated when a Markov jump process interferes with a deterministic nonlinear dynamics at random times and retains its state for a certain amount of time (dwell time). It is requested that the state estimation error of the switching dynamics asymptotically converges to zero with probability one.

Sensors, Measurements and Sensor Networks - Measurements devices, algorithms, data handling and transmission represent critical aspects in any distributed control problem. The number devices, their location, energy consumption, data-communication links, distributed data handling, are now days classical problems in this context. New issues deal with dynamic sensor networks, where mobile platforms are assimilated to intelligent devices. The formalization of the problem, in an intrinsically hybrid context, 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.

Projects:

- *Complex dynamical systems: elements of classification and case studies* - January 2007, June 2008 - UIF/UFI GALILEO Program.

- *Totally polymeric ionic transducers: applicability study, performance analysis and prototypical realizations for advanced sensor-actuator devices* - March 2010, December 2012 - MIUR PRIN.

- *Parameters identification and algorithms for WAMS in Italian high voltage Transmission network* - February 2008, June 2009 - TERNA.

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[23] Boilot J.-P., Fabbri F., Lahlil K., Lassailly Y., Monaco S. and Peretti J., Triggering and control on the kinetics of the different photoinduced deformation mechanisms in azo-polymer thin films. Submitted for pubblication.

3.12 Industrial Organization and Management

Research lines:

- Economics of Network Industries

- Competition, Regulation and Industrial Policy

- Mechanism Design and Auctions

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

- Management Control Systems

- Operations Management

Members: Alessandro Avenali, Domenico Laise, Claudio Leporelli (leader), Giorgio Matteucci, Fabio Nonino, Alberto Nastasi, Pierfrancesco Reverberi.

PhD Students: Tiziana D'Alfonso, Anna D'Annunzio.

Our research field includes general issues in industrial economics and management, with an emphasis on competition, regulation and investment in network industries. In particular, our research activity is at present focused on the following topics:

Regulation and competition in the telecommunication industry - We study the impact of access regulation on investment in a dynamic framework where developing an infrastructure requires both time and a captive customer base We define dynamic models to assess whether and when the *ladder of investment* regulatory paradigm induces efficient competitive network investment. In this framework we analyze the credibility and dynamic consistency of multiperiod regulated access price schedules. We also analyze the

impact of the industry structure (vertical integration or separation) on investment incentives and we assess if vertical separation of the telecommunications incumbent may be an effective and proportionate remedy when the access network is an enduring economic bottleneck.

Regulation and competition in the air transport industry - We study the incentives for airports and carriers to vertical cooperation and the effects of competitive pressures in both the airlines and airports markets over these incentives. Specifically, our findings provide theoretical and policy concerns with respect to the analysis of different contracts between airports and their respective dominant airlines and their effects in terms of social welfare, pro or anti competitiveness and the ensuing regulatory requirements.

Bundling - We show how a monopolist in a primary market uses mixed bundling to extract surplus from quality-enhancing investment by a single-product rival in a complementary market, or even force the rival to provide low quality. Although we assume that bundling creates efficiency gains, we find that bundling reduces consumer surplus and may reduce social welfare, even if the rival is not foreclosed, and investment is not blockaded. Nonetheless, bundling improves welfare when prevents inefficient investment. We propose to check bundled offers via a price test that controls the monopoly component stand-alone price to preserve efficiencies from both bundling and investment. When the rival invests, the test improves consumer surplus and welfare compared with the "do-nothing" scenario, or a ban on bundling.

E-procurement - We innovate procurement design related to outsourcing of facility management activities by developing a multi-attribute combinatorial auction-based mechanism which allows a procurer and sellers to dynamically and simultaneously bargain the characteristics of distinct procurement contracts. The proposed mechanism allows the procurer to mitigate the relevant problem concerning the lack of competences on the non-core activities, since it can partially extract from sellers their private information regarding both economic and technical issues.

Supply chain management - We carried out an exploratory case study in order to widen the knowledge basis on supply chain learning by exploring and explaining how an enterprise can compete and win in the international market by integrating the quality management practices along its supply chain and, above all, by becoming the coordinator in a supply chain learning (SCL) network. We found that the diffusion of a culture of quality sustains the supply chain learning towards the continuous improvement of product and service quality and, above all, can mitigate the companies' effort by creating an emergent behavior in the different actors that self-aligns their activity to a shared culture.

Social networks analysis - We studied the key roles embedded in the informal organizational structure (informal networks) outlining their contribution in the case study of a knowledge-based enterprise operating in the information systems industry. Furthermore we find and characterize a new key informal role that synthesizes problem solving, expertise, and accessibility characteristics.

Innovation management - We reviewed the literature on motivations in collaboration and we analyzed 26 open innovation web-based platforms which allow the collaboration of individuals and companies and the so-called crowdsourcing identifying the ef-

fects of "motivational systems" and platforms models on the attraction of the knowledge providers in the different phases of innovation process.

Knowledge strategy - We reviewed the three main strategies in the literature of knowledge management: the knowledge development (internal or external), the knowledge sharing (codification or personalization strategy) and the knowledge exploitation (internal or external) in order to propose a model and a three step methodology for assessing the coherence of companies' knowledge strategy to its business strategy and to its competitive and organizational context.

Multi-criteria managerial decision making - Our research illustrates the advantages of the multi-criteria methodology applied to managerial decision making problems. This methodology is founded on the notion of outranking to the benchmarking analysis of organizational learning capability.

Projects:

- *ISBUL - Infrastrutture e Servizi a Banda Larga e Ultra Larga* - January 2009, June 2010 - AGCOM (Autorità per le garanzie nelle comunicazioni).

- *COLLECTIVE - Emerging communities for collective innovation: ICT Operational tool and supporting methodologies for SME Associations* - January 2010, January 2013 - EU FP7.

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3.13 Modeling, Simulation, and Control in Biological and Biomedical Systems

Research lines:

- Optimal Estimation and Control Problems

- Analysis and Modelling of Metabolic Systems

- Methods and Techniques for Neuroengineering

- Computational Optimization and Optimal Control in Medicine and Biology

Members: Carlo Bruni, Alberto De Santis, Lorenzo Farina, Daniela Iacoviello, Serenella Salinari (leader).

PhD Students: Federico Papa, Valentina Russo, Ilenia Toppi.

Post Docs: Laura Astolfi.

The research activity in this area concerns the development of general methodologies of modelling, estimation and optimal control theory, as well as their application in the

study of biomedical and biological systems. Indeed, researches on biomedical applications were performed since the early 70's with regard to biomechanics, prostheses and modelling of cellular growth. At present, many groups in the Dpt. of Computers and System Sciences, are working in the above mentioned research lines at different levels of engagement. In this context, the main research topics are:

- Measurement policy in optimal filtering and control problems;

- Statistical modelling of rethinal data for diagnostic purposes;

- Modelling and Identification of tumour spheroids response to radiations;

- Analysis and modelling of glucose and lipid metabolism and their interaction;

- Estimation of cerebral connectivity in humans by means of structural and functional models;

- Implementation of devices for Brain Computer Interface based on parameters of the estimated cortical activity or on the real-time analysis of video-sequences;

- Medical image analysis, in particular aimed to develop segmentation methods able to enhance the retrieved information from different kind of images (mammographic data, pupil and liver tissue images etc.);

- Computational optimization in applicative topics of systems biology;

- Optimal density remodeling for stiffened lightweight structures.

The future activity of the group will mainly focus on the research on the optimal measurement times in the filtering problems, the study of the mechanisms on the basis of insulin secretion and on the insulin resistance; the investigation about the possible application of the Brain computer Interface techniques in the rehabilitation of stroke subjects; the utilization of the neuroengineering tools in the field of the economy/marketing; the optimization of tumour radiotherapy, the statistical procedures for automatic diagnosis of retinal pathologies, the analysis of the bone remodeling by finite element analysis and the optimization of its topology; the computational methods for the analysis of genome wide expression data and the topological features and criticalities in metabolic networks.

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

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3.14 Multi-Agent and Multi-Robot Systems

Research lines:

- Cooperation and Coordination

- Distributed Planning and Problem Solving

- Information Fusion and Situation Assessment

- Cognitive Human-Robot Interaction

- Multi-Agent/Robot Learning

- Cooperative Perception

Members: Giorgio Grisetti, Luca Iocchi, Daniele Nardi (leader), Giuseppe Oriolo, Marilena Vendittelli.

PhD Students: Ricardo Dodds, Antonio Franchi, Matteo Leonetti, Gabriele Randelli, Paolo Stegagno, Alberto Valero.

Post Docs: Domenico Bloisi, Daniele Calisi, Luca Marchetti, Vittorio Amos Ziparo.

The research in this area stemmed from the work on Cognitive Robotics and Artificial Intelligence, and the specific focus on multi-agent and multi-robot system has been originated by the participation in RoboCup competitions, starting back in 1998. The RoboCup competitions provide a very challenging experimental framework both for multi-robot systems and for (virtual) multi-agent systems. Consequently, the research developed in the area of Multi-Agent and Multi-Robot Systems has produced both theoretical results on several research problems as well as a number of prototype implementations.
The research topics addressed include:

- Cooperation and Coordination

- Distributed Planning and Problem Solving

- Information Fusion and Situation Assessment

- Cognitive Human-Robot Interaction

- Multi-Agent/Robot Learning

- Cooperative Perception

The implementation effort has been supported through OpenRDK, a software framework for the development of robotic applications, that has been released to the community (`http://openrdk.sourceforge.net`). The application domains, where the research ideas have been tested and experimentally evaluated, include virtual agents in search and rescue simulation and multi-robot systems in soccer, search and rescue, surveillance and domotics.

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

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

Projects:

- *GAPACOM: Sistema satellitare terra/bordo basato sullo studio di un payload NAVCOM innovativo da imbarcare sui satelliti GALILEO* (Ground/satellite system based on new NAVCOM payload for GALILEO satellites) - November 2008, December 2010 - Thales Alenia Space.

- *SAMAS: Sistema adattativo multi robot e sue applicazioni per lo sminamento - Servizi di cooperazione* (Adaptive multi-robot services and its applications to demining - Cooperation services) - March 2009, March 2010 - Space Software Italia.

- *MREM: Multi-Robot Teams for Environmental Monitoring* - May 2009, May 2010 - Dept. of Homeland Security (DHS), USA.

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3.15 Networked Systems

Research lines:

- Control of Networks, Control over Networks

- Control under Communication Constraints

- Modeling, Filtering and Optimal Control of Communication Networks

- Remote Control

Members: Stefano Battilotti, Carlo Bruni, Francesco Delli Priscoli (leader), Claudio De Persis, Alberto Isidori, Antonio Pietrabissa.

PhD Students: Andrea Fiaschetti, Laura Fogliati, Guido Oddi, Andi Palo, Martina Panfili, Margherita Petrocchi, Laura Pimpinella, Filippo Rodriguez, Marco Veroli.

Post Docs: Marco Castrucci, Alessandro Di Giorgio, Andrea Mercurio, Silvano Mignanti, Vincenzo Suraci.

The networked systems area has developed, in the last 10 years, even thanks to the successful participation in 30 major advanced research projects mainly financed by the European Union, and carried on together with the major European ICT players.

The research activities mainly deal with the design, simulation, and implementation of a technology independent "convergence layer" allowing the interoperation among heterogeneous networks (most of the activities concern telecommunication networks, but even large industrial networks, robotic networks, energy networks and transport networks are being considered), as well as the efficient and flexible handling of network resources and services/contents. Such a convergence layer, on the basis of the sensing of appropriate heterogeneous information (which can be subject to errors and could be limited) and its conversion and aggregation in homogeneous metadata, includes advanced control algorithms (methodologies such as bounded optimal control, predictive control and robust control are used) taking decisions concerning the management of the network resources, as well as the management of network contents/services; robustness of the controllers to uncertainties, as well as to delays and loss of information is a key issue of such control algorithms. These decisions are properly actuated in the network.

The networked systems area is supporting a Future Internet vision in which the convergence layer becomes a sort of "embedded mind" of the network; in this vision all network control tasks are gradually moved in such convergence layer allowing cross-layering, cross-network optimization. According to this vision, the present control layering stack, becomes a sort of star with the above-mentioned embedded mind being the center of the star.

Such a convergence layer is distributed among appropriate network entities (each one availing of a portion of the whole input information): thus, enhancement of distributed control algorithms is essential. The networked systems area plans to apply these concepts, in addition to telecommunication networks, to large-scale industrial networks, robotic networks, energy networks, and transport networks.

Projects:

- *P2P-Next, Next Generation Peer-to-Peer Content Delivery Platform* - January 2008, December 2011 - EU ICT FP7 Project.

- *pSHIELD, Pilot embedded System arcHItecturE for multi-Layer Dependable solutionS* - June 2010, May 2011 - EU ARTEMIS-JU Project

- *BRAVEHEALTH, Patient Centric Approach for an Integrated, Adaptive, Context Aware Remote Diagnosis and Management of Cardiovascular Diseases* (managed by CRAT - Consortium for the Research in Automation and Telecommunications) - March 2010, February 2013 - EU ICT FP7 Project.

- *OMEGA, Home Gigabit Access* (managed by CRAT) - January 2008, December 2010 - EU ICT FP7 Project.

- *P3C, Plug and Play Process Control Project* (managed by Aalborg University) - September 2006, August 2011 - Danish Research Council for Technology and Production Sciences.

- *Stability analysis and implementation of networked systems governed by Kuramoto oscillators* (2 consecutive projects) - September 2008, August 2010 - The Johns Hopkins University Applied Physics Laboratory.

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3.16   R&D, Innovation, and Internationalization

Research lines:

- Internationalization, Innovation and Environment

- R&D Coalitions and Innovation

- Obstacles to Innovation

Members: Maria Luisa Petit Tarascon, Francesca Sanna-Randaccio (leader), Roberta Sestini.

The group investigates the theoretical explanations and empirical implications of three interrelated phenomena:

1. technological innovation;

2. strategic behaviour of Multinational Enterprises (MNEs) in R&D intensive industries;

3. environmental and foreign direct investment (FDI) policies.

These research projects combine two strands of investigation previously followed by members of the group.

A first line of analysis concerned the study of R&D investment decisions, applying optimal control and dynamic game methods. The other line of enquiry dealt with different aspects of firms' choice of international strategy following a game-theoretic approach. These two streams of research have converged, producing in the more recent years a series of results concerning firms' innovative activities and international expansion via foreign direct investment (FDI).

Our paper published in the International Journal of Industrial Organization (2000) opened a new line of research in the literature, endogenizing for the first time the R&D choice in a model analyzing firms' international expansion decisions. The paper showed that multinational expansion incentivates R&D investment and that, in turn, investment in research increases the likelihood of multinational expansion.

This line of analysis has produced a number of developments (and of publications in international journals) where both static and dynamic game methods have been employed considering firms that operate in an international oligopoly set-up. We dealt with the impact of FDI on both home and host countries, with the choice of producing abroad when inter-firm transmission of knowledge is limited in space, with the effects of asymmetric spillovers and with the role of M&A in the case of internationalization in the service sector.

Furthermore, our study published in the Journal of International Business Studies (2007) is another important contribution, as it represents the first analytical model appeared in the literature on R&D internationalization, highlighting the drivers of this important phenomenon.

Our research plans for the next few years concern three topics. Firstly, we will deal with the effects of unilateral environmental policies on firms' decision to relocate production abroad and on their innovation and on technology transfer activities. This research stream addresses the phenomenon of "carbon leakage", which is a key policy issue both in the EU and the US.

Then we plan to undertake empirical investigation on some of the topics previously subject to theoretical investigation, carrying out an econometric analysis of the obstacles to innovation perceived by various categories of firms in different Italian macro-area. This empirical study, based on data from the Community Innovation Survey, will be part of a project of future collaboration with the London School of Economics and the SPRU, University of Sussex, U.K.

Besides, applying new mathematical tools (coalitions and networks theory), we will analyze the endogenous formation of R&D coalitions between firms. Our aim is to provide a model in which firms can decide not only to form a research joint venture, but also the timing of the investment in R&D. In other words, both the coalition formation process and the timing of the investment will be endogenized.

Conference Proceedings

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[2] Sanna-Randaccio F. and Sestini R., The Impact of Unilateral Environmental Policy with Endogenous Plant Location: the Role of Market Asymmetry and Transport Costs. *Proceedings of the 4th World Congress of Environmental and Resource Economists (WCERE 2010)*, June 28- July 2, Montreal, Canada, 2010.

Submitted papers, technical reports and others

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3.17   Robotics

Research lines:

- Robot Modeling, Planning, and Control

- Visual-based Control

- Sensor-based Planning and Exploration

- Navigation of Mobile Robots

- Networked Robots

- Physical Human-Robot Interaction

Members: Alessandro De Luca (leader), Luca Iocchi, Leonardo Lanari, Giuseppe Oriolo, Marilena Vendittelli.

PhD Students: Daniele Calisi, Fabrizio Flacco, Antonio Franchi, Pietro Peliti, Lorenzo Rosa, Paolo Stegagno.

Post Docs: Luca Marchetti, Chiara Toglia.

The Robotics group at DIS was established in the late '80s together with the Robotics Laboratory, and is committed to the development of planning and control techniques for manipulators and mobile robots.

Our main research topics are: nonlinear control of robots; iterative learning of repetitive motion; hybrid force/velocity control of manipulators interacting with the environment; optimization schemes in kinematically redundant robots; motion planning and control of wheeled mobile robots and other nonholonomic mechanical systems; stabilization of underactuated robots; robot actuator fault detection and isolation; safe control of physical human-robot interaction; control of manipulators with flexible elements; control of locomotion platforms for VR immersion; image-based visual servoing; sensor-based navigation and exploration in unknown environments; motion planning for high-dimensional systems; multi-robot coordination and mutual localization.

In addition to further development in the above mentioned areas, recent activities include control and visual servoing for unmanned aerial vehicles (UAV), control-based motion planning for mobile manipulators, motion planning and control of humanoid robots, and sensory supervision of human-robot interaction. We also pursue more applied research, such as the development of a large team of mobile robots for luggage transport in airports and the design of an autonomous GPS-guided line tracer for road surface marking.

All research activities undergo experimental validation in our Robotics Laboratory, that currently provides two manipulators (a 6R industrial robot by KUKA and a Pendubot by Quanser) and a number of mobile robots, including both wheeled (a Magellan-Pro by iRobot and a team of five Khepera-III by K-team) and legged (2 quadruped Sony

AIBOs) platforms. Moreover, a Hummingbird quadrotor helicopter by AscTec is available. All these robots are equipped with sensing devices of various complexity, going from ultrasonic/laser range finders to stereo vision systems. In the past, we have also designed and built a two-link flexible manipulator (FlexArm) and a differentially-driven wheeled mobile robot (SuperMARIO).

Projects:

- *I-MULE* - 2011–2015 - Industria 2015: Nuove Tecnologie per il Made in Italy.

- *MEMONET, Multirobot Exploration supported by MObile ad-hoc NETworks* - March 2010–September 2012 - MIUR PRIN.

- *SICURA, Sicurezza per l'Interazione nel Contatto Robot-Ambiente* (Safe Physical Interaction between Robots and Humans) - September 2008–September 2010 - MIUR PRIN.

- *PHRIENDS, Physical Human-Robot Interaction: Dependability and Safety* - October 2006–September 2009 - EU FP6 STREP.

- *CyberWalk, The CyberCarpet - Enabling Omni-directional Walking in Virtual Worlds* - April 2005–May 2008 - EU FP6 STREP.

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[13] Chaumette F., Cherubini A. and Oriolo G., Visual servoing for path reaching with nonhololonomic robots. Submitted to *Robotica*, December 2010.

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3.18   Robust and Nonlinear Control

Research lines:

- Nonlinear Regulation

- Stabilization of Nonlinear Systems

- Dynamic Feedback Linearization

- Robust Control

- Quantized Control

- Nonlinear Control Applications

Members: Stefano Battilotti, Claudia Califano, Francesco Delli Priscoli, Claudio De Persis, Alberto Isidori (leader), Salvatore Monaco.

Post Docs: Fabio Celani, Alessandro Di Giorgio.

Research on nonlinear and robust control at the University Sapienza has been active since the early 70s and, historically, has played a major role worldwide. The geometric approach to nonlinear feedback design, developed in the late 70s, marked the beginning of a new area of research which, in the subsequent decades, has profoundly influenced the development of the entire field. The concept of (nonlinear) feedback equivalence and of zero dynamics, their properties and implications in feedback design, are perhaps the most frequently used concepts in feedback stabilization. The geometric approach

also plays a fundamental role in the analysis of systems evolving on Lie groups, with numerous applications to the control of spacecrafts and mobile robots. The natural evolution of the geometric approach to analysis and design of nonlinear systems led to a refinement of concepts underlying the design of nonlinear controllers to the purpose of shaping the steady-state behavior of a system. Currently, this line of research is pursued with the study of problems arising in the regulation of systems possessing unstable zero dynamics and in the development of methods for robust stabilization via measurement feedback. A general framework for robust stabilization reposes of the concept of filtered Lyapunov functions. The main feature of filtered Lyapunov functions is that they are easy to construct and combine, even for non-triangular systems, to obtain composite Lyapunov functions, which may be used for Lyapunov-based design of stabilizing controllers. Tools for the design of composite filtered Lyapunov functions have been developed. Robust and nonlinear control techniques have proven useful to achieve control objectives in the case of restricted information structure, e.g. measurements taking values only in a finite set and/or feedback delivered to the actuators erratically. The main problems here include the characterization of the minimal amount of information needed to achieve a prescribed control goal and the robustness of the controllers to process uncertainties as well as delays and loss of information. Output regulation for systems having unstable zero dynamics is pursued by means of a systematic reduction approach, in which the degrees of freedom in the design of the internal model design are optimized to simplify the task of stabilizing the associated steady-state manifold. In particular, it is expected that the analysis will shed a new light on the problem of characterizing the limits of performance in the control of non-minimum phase systems, in particular with respect to the problem of tracking/rejecting recurrent exogenous inputs. Advances in robust stabilization are based on a thorough investigation of the property of non-homogeneity, putting in a unifying framework existing semiglobal stabilization and observer design results based on homogeneity and system triangularity, and giving new results based on non-homogeneity. A major challenge in the research on control with limited information is the design of controllers which are distributed over a network. In this case, the controllers cooperate to achieve a common goal but have access only to limited information provided by their neighbors. Applications include control of large-scale industrial networks, cooperative control of multi-robots and distributed estimation.

Projects:

- *Stability analysis and implementation of networked systems governed by Kuramoto oscillators* (2 consecutive projects) - September 2008, August 2010 - The Johns Hopkins University Applied Physics Laboratory.

- *Advanced Methods for Feedback Control of Uncertain Nonlinear Systems* - 2008 - MIUR.

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Patents

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3.19 Web Algorithmics and Data Mining

Research lines:

- Web Search and Mining

- Graph and Text mining

- Large-scale Complex Networks

- On-line Social Networks

- Algorithmic Mechanism Design and Network Economics

Members: Luca Becchetti, Stefano Leonardi (leader).

PhD Students: Ilaria Bordino, Ida Mele.

Post Docs: Aris Anagnostopoulos, Piotr Sankowski.

Our interest in on algorithmic methods for characterizing the structure of large-scale complex networks with application to Web structure mining and Web usage mining. We have focussed so far on developing algorithms for graph based feature extraction and detection of significant patterns that characterize social activities, trust relationships and content quality.

In cooperation with Yahoo! Research group in Barcelona, we developed, analyzed and tested effective, scalable and efficient techniques for the automatic detection of topological structures in the Web graph that are likely to be the result of spamming activity. This research has been expanded to provide efficient methods to estimate the distribution of small substructures that are typically related to specific forms of social interaction. We also developed algorithmic methods for the extraction of meaningful information from the massive data available in query logs, a task of critical importance for detecting semantic relations between users, queries and pages. The design and analysis of economic mechanisms in the realm of the Internet and the Web and the computational issues of implementing economic mechanisms, as for instance ad auctions for on-line advertising, is another major research direction of our group. In the last few years we have concentrated our efforts in the area of the design of efficient cost-sharing and utilitarian mechanisms for network design, single and multi-objective optimization problems.

The Web has evolved from an excellent medium for sharing information into a complex and attractive social environment for the delivery of content rich information, products and services. In this respect, mining social network data for enhancing and personalizing web search and retrieval is a major research direction. Development of algorithmic strategies and analytic tools for influence spreading, viral marketing and technology adoption is of crucial importance for many computer mediated collaboration and commercial activities. E- commerce applications also require the implementation of economic mechanisms that address new problems, such as computerized auctions for Web ads.

Marketing on the Web also requires sophisticated algorithmic tools for mining the huge amount of user activity data collected from search engines and other applications, for the identification of important trends or to provide fundamental tools, such as recommendation services. Finally, Web size and the increasing importance of the above applications pose serious scalability issues that we are going to tackle, such as the development of sophisticated ads and query caching techniques.

Projects:

- *DELIS, Dynamically Evolving Large Scale Information Systems* - January 2004, February 2008 - EU FP6 FET.

- *WEB RAM - Web Retrieval and Mining* (Projects managed by the Computer Science Department) - January 2007, December 2008 - MIUR PRIN.

- *COGENT - COmputational and GamE-theoretic aspects of uncoordinated NeTworks* - October 2008, September 2012 - MIUR PRIN.

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[15] Fiat A., Leonardi S., Saia J. and Sankowski P., Combinatorial auctions with budgets. Submitted to *ACM Electronic Commerce (EC11)*, 2011.