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 2009

DIPARTIMENTO DI INFORMATICA
E SISTEMISTICA ANTONIO RUBERTI

SAPIENZA
UNIVERSITÀ DI ROMA

Research report 2009

Dipartimento di Informatica e Sistemistica
Antonio Ruberti

http://www.dis.uniroma1.it

Dipartimento di Informatica e Sistemistica Antonio Ruberti

Dipartimento di Informatica e Sistemistica Antonio Ruberti
Sapienza Università di Roma

Research report 2009

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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 2009.

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, systems, 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 2009 consists of 30 full professors, 18 associate professors, and 16 assistant professors (ricercatori). They provide education at the undergraduate and graduate levels to several programs of the School of Engineering at Sapienza, with main responsibility in the curricula in informatics, systems and control, and management. The teaching activity is 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.

During 2009, the research at DIS has been organized in 19 research areas. This organization is reflected in the structure of Section 3, where the research areas are described with an illustration of their main research lines, together with the list of people involved, and the collection of publications appeared in 2009.

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 2009, the DIS library continued the organization of the series of invited lectures *Incontri al Chiostro*, under the supervision of Professor Claudio GORI GIORGI until August 2009 and professors Marilena VENDITTELLI and Alberto MARCHETTI SPACCAMELA starting from September. The lectures of 2009 were:

Walter MARASCHINI	Bravi in matematica	Apr. 20, 2009
Federico ENRIQUES	Castelli di carte	Apr. 27, 2009
Giorgio ISRAEL	I nemici della scienza	May 6, 2009
Francesco BERTO	Mente contro computer: Godel e l'AI	May 25, 2009
Massimo CENCINI	Caso, caos e predicibilità.	Dec. 10, 2009

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

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 laboratories 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

Administration head - Maria Pia VANDILLI

Faculty

Professors
Giorgio AUSIELLO
Roberto BALDONI
Stefano BATTILOTTI
Carlo BRUNI
Luigia CARLUCCI AIELLO
Tiziana CATARCI
Bruno CICIANI
Alessandro DE CARLI
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
Alberto DE SANTIS
Lorenzo FARINA
Domenico LAISE
Leonardo LANARI
Paolo LIBERATORE
Carlo MANNINO
Giuseppe ORIOLO
Laura PALAGI
Pier Luigi PICCARI (until October 2009)
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
Paolo DI GIAMBERARDINO
Daniela IACOVIELLO
Luca IOCCHI
Domenico LEMBO
Giorgio MATTEUCCI
Massimo MECELLA
Leonardo QUERZONI
Roberta SESTINI
Marilena VENDITTELLI
Andrea VITALETTI

Contract professors
Fabio CELANI (until October 2009)

Staff

Research associates and post docs
  Carola AIELLO
  Aris ANAGNOSTOPOULOS
  Laura ASTOLFI
  Anna BELARDINELLI
  Yann BUSNEL
  Silvia CANALE
  Massimiliano DE LEONI
  Giorgia LODI
  Sara MATTIA
  Silvano MIGNANTI
  Fabio PATRIZI
  Pietro PELITI
  Antonio PIETRABISSA
  Antonella POGGI
  Francesco RINALDI
  Marco RUZZI
  Piotr SANKOWSKY
  Sirio SCIPIONI
  Vincenzo SURACI
  Vittorio Amos ZIPARO

Administration staff
  Amelia ARRICALE
  Flavia CAGNIZI
  Antonietta CANGELLI
  Beatrice DE CARLO
  Giuditta FILOMENA (starting January 22, 2009)
  Sabrina GIANPAOLETTI (starting June 30, 2009)
  Tiziana VALENTINI
  Maria Pia VANDILLI

Technical staff
  Anna Paola DI RISIO (on leave)
  Giuseppe FILACI
  Marcello PANI
  Tiziana TONI

Auxiliary services
  Pia BONANNI
  Antonio SIMEONI

Librarian
  Laura ARMIERO

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 DEIS (the Department of Electric, Computer and System Sciences) of the University of Bologna, in Operations Research, hosted by the Department of Probability and Statistics of the Sapienza University of Rome, 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)

XXI course

Eugenio MATTEI

New admissions for the XXV course are:

Jlenia TOPPI

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

XXII course	XXIII course	XXIV course
Beniamino ACCATTOLI	Andrea CARBONE	Lorenzo BERGAMINI
Domenico BLOISI	Ugo Maria COLESANTI	Claudio CORONA
Silvia BONOMI	Matteo DI GIOIA	Pierangelo DI SANZO
Ilaria BORDINO	Matteo LEONETTI	Luca FILIPPONI
Daniele CALISI	Stefano MARRA	Letizia MARCHEGIANI
Alberto VALERO GOMEZ	Matia PIZZOLI	Roberto PALMIERI
Shah Rukh HUMAYOUN	Gabriele RANDELLI	Marco PLATANIA
Domenico Davide LAMANNA		Domenico Fabio SAVO
Stefano PELLEGRINI		

New admissions for the XXV course are:

Nicola CATENACCI VOLPI
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

Economics and Management of Technology

DIS participates in the PhD program in Economics and Management of Technology coordinated 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
Anna D'ANNUNZIO

New admissions for the XXV course are:

Tiziana D'ALFONSO

Operations Research

The council of professors of the PhD program in Operations research is coordinated by the Department of Probability and Statistics of Sapienza.
The research topics are: Combinatorial optimization, nonlinear programming, network design, neural networks, logistics, management systems, and industrial systems economy.

PhD students (working at DIS)

XXII course	XXIII course	XXIV course
Fabio D'ANDREAGIOVANNI	Serena TEBALDO	Marianna DE SANTIS
		Andrea IANNI
		Carla MICHINI
		Mauro PIACENTINI

New admissions for the XXV course are:

Stefania DE ANGELIS
Vittorio LATORRE
Simone SAGRATELLA

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
Simone ASNAGHI	Giuseppe ORSINI	Laura FOGLIATI
Marco CASTRUCCI	Laura PIMPINELLA	Fabrizio FLACCO
Alessandro DI GIORGIO	Filippo RODRIGUEZ	Lorenzo LAMPARIELLO
Antonio FRANCHI	Valentina RUSSO	Federico PAPA
Enrico GENTILI	Fernando TIEFENSEE	Mattia PETRUCCIANI
	Marco VEROLI	Simone SAGRATELLA
		Paolo STEGAGNO

New admissions for the XXV course are:

Andrea ABELLI
Andrea FIASCHETTI
Pietro PELITI
Guido ODDI
Marco PAOLETTI
Daniele PUCCI
Antonio D'ANGELO

PhD theses completed in 2009

Bioengineering

Eugenio MATTEI
Study of the thermal effects induced by magnetic resonance on endocardial leads: numerical models and experimental validation
Advisor: Serenella SALINARI
March 2009

Computing Science and Engineering

Anna BELARDINELLI
Salience features selection: Deriving a model from human evidence
Advisor: Fiora PIRRI
February 2009

Antonella CHIRICHIELLO
Two Formal Approaches for Web Services: Process Algebras & Action Languages
Advisor: Marco SCHAERF
October 2009

Massimiliano DE LEONI
Adaptive Process Management in Highly Dynamic and Pervasive Scenarios
Advisor: Tiziana CATARCI
October 2009

Marco FRATARCANGELI
A Computational Musco-Skeletal Model for Animating Virtual Faces
Advisor: Marco SCHAERF
October 2009

Luca MARCHETTI
To believe or not to believe: Improving distributed data fusion with second order knowledge
Advisor: Luca IOCCHI
October 2009

Adnan NOOR MIAN
Distributed Search and Service Discovery in Wireless Ad Hoc Networks using Random Walk
Advisor: Roberto BALDONI
October 2009

Fabio PATRIZI
Simulation-based Techniques for Automated Service Composition
Advisor: Giuseppe DE GIACOMO
October 2009

Sirio SCIPIONI
Algorithms and Services for Peer-to-Peer Internal Clock Synchronization
Advisor: Roberto BALDONI
October 2009

Giuseppe Paolo SETTEMBRE
Multi-agent approach to situation assessment
Advisor: Daniele NARDI
October 2009

Gian Diego TIPALDI
Looking inside for mapping the outside: Introspective Simultaneous localization and mapping
Advisor: Daniele NARDI
February 2009

Operations research

Francesco RINALDI
Mathematical Programming Methods for Minimizing the Zero Norm over Polyhedral Sets
Advisor: Marco SCIANDRONE
May 2009

Systems Engineering

Filippo FABBRI
Movimento fotoindotto in nanosistemi di tipo azobenzene: problemi connessi alla modellistica ed al controllo
Advisor: Salvatore MONACO
March 2009

Simone GABRIELE
Dynamical area coverage by mobile sensors networks: analysis, modelling and control
Advisor: Paolo DI GIAMBERARDINO
March 2009

Silvano MIGNANTI
Reinforcement learning algorithms for technology independent resource management in next generation networks: connection, admission, control procedures
Advisor: Francesco DELLI PRISCOLI
March 2009

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 2009.

Sam BURER, University of Iowa, USA (April - May)
Alan DIX, Lancaster University, UK (April - May)
Tom N. JENSEN, Aalborg University, Denmark (March)
Dennis G. LUCARELLI, The Johns Hopkins University, USA (May)
Sean LUKE, George Mason University, USA (July - September)
María Guijarro MATA-GARCIA, Universidad Complutense de Madrid, Spain (July)
Shmuel ZAKS, Technion Haifa, Israel (January - February)
Christian KANZOW, University of Wrzburg, Germany (November)

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.)

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

- E.U., 101.737, VIEW-FINDER, Vision and Chemiresistor Equipped Web-connected Finding Robots, F. Pirri (up to 30/11/09).

- E.U., 240.000, SEMANTICGOV, Providing Integrated Public Services to Citizens at the National and Pan-European level with the use of Emerging SemanticWeb Technologies, R. Baldoni (up to 30/04/09).

- E.U., 196.489, PHRIENDS, Physical Human-Robot Interaction: depENDability and Safety, A. De Luca (up to 30/09/09).

- E.U., 160.335, RESIST, Resilience for Survivability in IST, R. Baldoni (up to 31/03/09).

- E.U., 322.500, WORKPAD, An Adaptive Peer-to-Peer Software Infrastructure for Supporting Collaborative Work of Human Operators in Emergency/Disaster Scenarios, T. Catarci (up to 31/08/09).

- E.U., 54.420, PANORAMA, Pervasive Adaptation Network for the Organisation of the Research Agenda and The Management of Activities, A. Marchetti Spaccamela (up to 31/01/11).

- E.U., 200.000, FRONTS, Foundations of AdaptiveNetworked Societies of Tiny Artefacts, A. Marchetti Spaccamela (up to 31/01/11).

- E.U., 256.512, P2P-NEXT, Next Generation Peer-to-Peer Content Delivery Platform, F. Delli Priscoli (up to 31/12/11).

- E.U., 20.491, VisMaster CA, Visual Analytics Mastering the Information Age, G. Santucci (up to 31/07/2010).

- E.U., 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).

Contracts with Italian Institutions

- RCOST-UNISANNIO, 207.900, FISR Progetto INTERAGRO, Metodi e Strumenti per la supply chain INTEgRata nell'AGRO alimentare, A. Sassano (up to 05/12/09).

- MIUR, 380.800, APICE - Algoritmi per la Pianificazione Integrata e Controllo di reti wireless Eterogenee, F. Delli Priscoli (up to 30/06/09).

- MIUR, 36.500, MAINSTREAM - Algoritmi per strutture informative di grandi dimensioni e "data streams", G. Ausiello (up to 31/01/09).

- MIUR, 33.585, SICURA - Sicurezza per l'Interazione del Contatto tra Umani, Robot e Ambiente, A. De Luca (up to 21/09/10).

- MIUR, 346.186, eG4M - eGovernment for Mediterranean Countries, T. Catarci and R. Baldoni (up to 30/04/09).

- MIUR, 225.000, FIRB RBIN047MH9, International Italian-Israelian cooperation, A.Marchetti Spaccamela (up to 31/7/09).

- MIUR, 28.000, PRIN: Ottimizzazione Nonlineare, Disequazioni Variazionali e Problemi di Equilibrio, G. Di Pillo (up to 21/09/2010).

Contracts with companies

- MINISTERO DELLA GIUSTIZIA, 113.034, Supporto scientifico e supervisione per la revisione e la realizzazione dei sistemi di infrastruttura per il processo telematico del Ministero della Giustizia, R. Baldoni (up to 18/10/09).

- DIP. DI INGEGNERIA-Università degli Studi del Sannio, 80.000, Studio e sviluppo di data mining per problemi di gestione e controllo di reti di telecomunicazioni, A. Sassano (up to 31/2/09).

- ELSAG-DATAMAT, 375.000, Studio/Ricerca per il progetto "M3-CAST" Servizi mobili multimediali in Multicast su reti DVB-T e UMTS, F. Delli Priscoli (up to 23/02/09).

- 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).

- SOFTWARE ITALIA SPA, 47.400, Studio/Ricerca sul tema SAMAS "Sottosistema di cooperazione", D. Nardi (up to 25/01/2010).

- AUTORITÀ PER LE GARANZIE NELLE COMUNICAZIONI , 61.650, Studio/Ricerca sul tema: "Infrastrutture e servizi a banda larga e ultra larga", D. Nardi (up to 31/10/09).

- DUEL SPA,10.000, Studio/Ricerca sul tema: "Dotto story teller: sistema di rappresentazione della conoscenza e ragionamento", D. Nardi (up to 07/12/2009).

- 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).

- 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)

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)

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 2009, in chronological order. Also the Workshops organized at DIS are reported, with the exception of the project meetings.

- January 15, Leonardo Querzoni, Sapienza Università di Roma, *Distributed Uniform Peer Sampling*.

- January 19, *Service Science and Computer Science Faculty Award Event*, organized by Sapienza Università di Roma and IBM Italia.

- January 21, Jong-Shi Pang, Illinois University, *On Linear Programs with Linear Complementarity Constraints*.

- February 5, Giuseppe Timpano, The OpenNetwork team, *OpenNetwork - Le nuove frontiere della comunicazione 2.0*.

- February 5, Romain Daros, Aldebaran Robotics, *Meet Nao Humanoid Robot*.

- February 12,16,17 and March 23-25, Shmuel Zacks (Technion Haifa) and Jared Saia (University of New Mexico), *Selected topics in distributed computing*.

- February 25, Chiara Toglia, Sapienza Università di Roma, *Use of Teams of Robots in Orbit*.

- March 5, Yael Dubinsky, IBM Haifa Research Lab, *Manage User Evaluation in Software Development Environments*.

- March 23, Kevin Lynch, Northwestern University, *Robot Assembly: From Vibratory Manipulation to Self-Organization*.

- April 2, Massimiliano de Leoni, Sapienza Università di Roma, *Adaptive Process Management in Highly Dynamic and Pervasive Scenarios*.

- April 16, Fabio Patrizi, Sapienza Università di Roma, *Simulation-based Techniques for Automated Service Composition*.

- April 29, Alessandro Saffiotti, Orebro University, *Navigating by Stigmergy: A Realization on an RFID Floor for Minimalistic Robots*.

- April 30, Alan Dix, Lancaster University, *The Power of Regret: Cognitive and Computational Models*.

- May 7-22, Sam Burer, University of Iowa, *Short course on Semidefinite Programming*.

- May 14, Alberto Sarti, Selex Galileo, *Lezione Magistrale sulle prospettive di ricerca e di sviluppo di nuove tecnologie nell'impresa*.

- May 15, David Pearce, Universidad Politécnica de Madrid, *60 anni di modelli stabili*.

- May 19, Davide Frey, INRIA Rennes-Bretagne Atlantique, *HEAP: HEterogeneity-Aware Gossip Protocol*.

- May 28, Workshop *Dalla ricerca all'innovazione: l'Università protagonista della crescita*.

- June 3, Gabriel Antoniu, INRIA Rennes-Bretagne Atlantique, *BlobSeer: Enabling High Data Throughput under Heavy Access Concurrency on Distributed Infrastructures Through Decentralized Data and Metadata Management*.

- June 22, Jorge Pereira, European Commission DG INFSO, *WSNs and Cooperating Objects in FP7 and Beyond - the next steps*.

- July 7, Adrian R. Pearce, University of Melbourne, *The collaborative logic programming problem and deductive-inductive resolution*.

- July 16, Yves Lesperance, York University, *Incremental Plan Recognition in an Agent Programming Framework*.

- July 23, María Guijarro Mata-Garci, Universidad Complutense de Madrid, *A hybrid classifier for natural images*.

- September 8-15, Maarten Van Steen (Vrije Universiteit Amsterdam) Roberto Beraldi and Leonardo Querzoni (Sapienza Università di Roma), *Gossiping in large-scale distributed systems*.

- October 15, Michael Wooldridge, University of Liverpool, *Professor Kripke, let me introduce Professor Nash: Logic for Economic Mechanism Design*.

- November 24, Aharon Ben-Tal, Technion Haifa, *Robust Solutions of Uncertainty Affected Conic Optimization Problems* and *Some Remedies for Some Intractable Optimization Problems*.

- December 2, Michele Maini, *Fattori umani nel controllo di processo*.

- December 3, Sean Luke, George Mason University, *Metaheuristics, Evolutionary Algorithms, and Coevolution*.

- December 9, *La ricerca al DIS: presentazione agli studenti*.

- December 14-18, *The 5th workshop on Internet and network Economics (WINE 2009)*.

- December 15, Anton Shiriaev, Umea University, *On Motion Planning, Motion Representation and its Orbital Stabilization for Mechanical Systems*.

- December 15, Terry Heath, IBM T.J. Watson Research Center, *Siena: a tool for modeling and executing artifact-centric business processes*.

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.

- February 2 at DIS, Jochen Koenemann, University of Waterloo, *Approximating Crossing Spanning Trees – Using Cut Structure to Refine Iterative Rounding*.

- February 23 at DI, Daniel Wichs, New York University, *Non-Malleable Extractors and Symmetric Key Cryptography from Weak Secrets*.

- March 2 at DIS, Jared Saia, University of New Mexico, *On the design of robust, large-scale networks*.

- March 16 at DIS, Amos Fiat, Tel Aviv University, *Justice, Truth and Makespan*.

- March 23 at DIS, Piotr Krysta, Liverpool University, *Approximability of Pricing Problems*.

- March 30 at DI, Mauro Sozio, Max Planck Institut fuer Informatik, *Near-Optimal Dynamic Replication in Unstructured Peer-to-Peer Networks*.

- April 6 at DI, Bertrand Guenin, University of Waterloo, *Isomorphism theorems for even cycles and even cuts in graphs*.

- April 20 at DIS, Silvio Lattanzi, Sapienza Università di Roma, *Affiliation Networks*.

- May 4 at DIS, Flavio Chierichetti, Sapienza Università di Roma, *Compression and caching for efficient web retrieval*.

- October 26 at DIS, Gianni Franceschini, Sapienza Università di Roma, *Partial Sorting Problems on Suffixes*.

- November 30 at DI, Paolo Boldi, University of Milano, *Search engines: Query logs, query-flow graphs and query-reformulation classification*.

2.7 Awards

- Alessandro De Luca, Daniele Nardi and Giuseppe Oriolo, as authors of three chapters in the "Springer Handbook of Robotics", received the two *PROSE Awards for Excellence in Physical Sciences & Mathematics* and *for Engineering & Technology*, The American Publishers Awards for Professional and Scholarly Excellence, February.

- Luigia Carlucci Aiello, *Donald E.Walker Distinguished Service Award "for her substantial contributions and extensive service to the field of Artificial Intelligence throughout her career"*, International Joint Conferences on Artificial Intelligence (IJCAI), July.

- Carlo Mannino and Alessandro Mascis, *Excellence in Practice Award*, European Association of Operational Research Societies, July.

- Daniele Nardi, *ECCAI Fellowship*, European Coordinating Committee for Artificial Intelligence, August.

- Giuseppe De Giacomo, *IBM Open Collaborative Faculty Award*, IBM, October.

- Maurizio Lenzerini, *Sapienza Ricerca Award*, Sapienza Università di Roma, October.

- Alberto Isidori, *Honorary Doctor*, KTH Royal Institute of Technology, November.

- Claudio De Persis, *General Chairs' Recognition Award for Interactive Papers*, The Combined 48th IEEE Conference on Decision and Control and 28th Chinese Control Conference, December.

- Maurizio Lenzerini, *Fellow of the ACM*, Association for Computing Machinery, December.

- Gian Diego Tipaldi, *Premio per NeoDottori di Ricerca "Marco Cadoli"*, Associazione Italiana per l'Intelligenza Artificiale, December.

- Riccardo De Masellis, *Premio Neolaureati 2009*, Associazione Italiana per l'Intelligenza Artificiale (AI*IA).

- Alberto Isidori, *Premio Galileo Galilei per la Scienza*, Rotary Club Italia.

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:

- *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.

Journals

[1] Acuña V., Chierichetti F., Lacroix V., Marchetti-Spaccamela A., Sagot M. F. and Stougie L., Modes and cuts in metabolic networks: Complexity and algorithms. *Biosystems*, 95(1):51–60, 2009.

[2] Ausiello G., Bourgeois N., Giannakos A. and Paschos V. Th., Greedy Algorithms for On-Line Set-Covering. *Algorithmic Operations Research*, 4(1):36–48, 2009.

[3] Ausiello G., Demetrescu C., Franciosa P. G., Italiano G. F. and Ribichini A., Graph Spanners in the Streaming Model: An Experimental Study. *Algorithmica*, 55(2):346–374, 2009.

[4] Ausiello G., Escoffier B., Monnot J. and Paschos V. Th., Reoptimization of minimum and maximum traveling salesman's tours. *Journal of Discrete Algorithms*, 7:453–463, 2009.

[5] Ausiello G., Franciosa P. G. and Italiano G. F., Small Stretch (a, b)-Spanners in the Streaming Model. *Theoretical Computer Science*, 410:3406–3413, 2009.

[6] Bonifaci V. and Stougie L., Online k-server routing problems. *Theory of Computing Systems*, 45(3):470–485, 2009.

[7] Demetrescu C., Finocchi I. and Ribichini A., Trading Off Space for Passes in Graph Streaming Problems. *ACM Transactions on Algorithms*, 6(1):1–17, 2009.

[8] Díaz F., Grandoni F. and Marchetti-Spaccamela A., Balanced cut approximation in random geometric graphs. *Theoretical Computer Science*, 410:27–29, 2009.

Articles in books

[9] Carrara G., Fioravanti A. and Nanni U., An innovative knowledge structure for supporting collaboration in building design. *Beheshti R., Dato E. and Khaldoun Z., Innovation for Building and Construction. Towards a better, stronger and sustainable future using advanced ICT*, pp. 331–350, Paris, Europia, 2009. ISBN/ISSN: 978-2-909285-56-1.

Submitted papers, technical reports and others

[10] Demetrescu C., Finocchi I. and Ribichini A., Make Your Memory Reactive: Integrating One-Way Dataflow Constraints into the C Language. *Manuscript*, 2009.

[11] Grandoni F., Krysta P., Leonardi S. and Ventre C., Utilitarian Mechanism Design for Multi-Objective Optimization. *Proc. of the 19th Annual ACM-SIAM Symposium on Discrete Algorithms* (SODA 2010), to appear.

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:

- *TONES: Thinking Ontologies* - September 2005, December 2008 - EU FP6.

- *ROBOCARE: ROBOtics for the CARE of elderly and disable people* - 2003, 2007 - MIUR.

Journals

[1] Botta F., Randelli G., Saracini C. and Valero A., Spatial processes in mobile robot teleoperation. *Cognitive Processing*, 10(2):338–341, 2009.

[2] Calisi D., Iocchi L., Nardi D., Randelli G. and Ziparo V.A., Improving Search and Rescue Using Contextual Information. *Advanced Robotics*, 23(9):1199–1216, 2009.

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[4] Cherubini A., Giannone F., Iocchi L., Lombardo M., Oriolo G., Policy gradient method for a humanoid soccer robot. *Robotics and Autonomous Systems*, 57:808–818, 2009.

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[9] Calvanese D., De Giacomo G., Lembo D., Lenzerini M. and Rosati R., Conceptual modeling for data integration. In Borgida A., Chaudhri V. K., Giorgini P. and Yu E. S. K., editors, *Conceptual Modeling: Foundations and Applications - Essays in Honor of John Mylopoulos*, volume 5600 of LNCS, pp 173–197, 2009.

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[11] De Giacomo G., Lesperance Y., Levesque H. and Sardina S., Indigolog: A high-level programming language for embedded reasoning agents. In Bordini R., Dastani M., Dix J. and El Fallah Seghrouchni A., editors, *Multi-Agent Programming: Languages, Tools and Applications*, pp. 31–72, Springer, 2009.

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[12] Iocchi L., Matsubara H., Weitzenfeld A. and Zhou C., editors, *RoboCup 2008: Robot Soccer World Cup XII.* Springer LNAI 5399, ISBN: 978-3-642-02920-2, 2009.

Conference proceedings

[13] Botta F., Mecella M., Randelli G., Saracini C. and Valero A., The Advantage of Mobility: Mobile Tele-operation for Mobile Robots. *Proc. of the AISB 2009 Convention*, Edimburgh, Scotland, UK, 2009.

[14] Botta F., Nardi D., Randelli G., Saracini C. and Valero A., Give me the control, I can see the robot!. *Proc. of IEEE Int. Workshop on Safety, Security, and Rescue Robotics* (SSRR), Denver, CO, USA, 2009.

[15] Calvanese D., De Giacomo G., Hull R. and Su J., Artifact-centric workflow dominance. *Proc. of the 7th Int. Conf. on Service Oriented Computing* (ICSOC '09), pp. 130–143, Stockholm, S, 2009.

[16] Calvanese D., De Giacomo G., Lenzerini M. and Vardi M. Y., An automata-theoretic approach to regular xpath. *Proc. of the 12th Int. Symposium on Database Programming Languages* (DBPL '09), volume 5708 of LNCS, pp. 18–35, Springer, Lyon, F, 2009.

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[19] De Giacomo G., Lenzerini M. and Rosati R., On higher-order description logics. *Proc. of the 22nd Int. Workshop on Description Logics* (DL '09), Oxford, UK, 2009.

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[21] De Giacomo G. and Patrizi F., Composition of services that share an infinite-state blackboard (extended abstract). *Proc. of IJCAI 2009 Workshop on Information Integration on the Web* (IIWEB '09), Pasadena, CA, USA, 2009.

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[23] De Giacomo G. and Sardina S., Composition of congolog programs. *Proc. of the 21st Int. Joint Conf. on Artificial Intelligence* (IJCAI '09), pp. 904–910, Pasadena, CA, USA, 2009.

[24] De Leoni M., De Giacomo G., Lesperance Y. and Mecella M., On-line adaptation of sequential mobile processes running concurrently. *Procòf the 24th Annual ACM Symposium on Applied Computing* (ACM-SAC '09), pp. 1345–1352, Waikiki Beach, Honolulu, HI, USA 2009.

[25] Farinelli A., Nardi D., Pigliacampo R., Rossi M. and Settembre G. P., Solving disagreements in a Multi-Agent System performing Situation Assessment. *Proc. of 12th Int. Conf. on Information Fusion* (IF '09), pp. 717–724, Seattle, WA, 2009.

[26] Nardi D., Pigliacampo R. and Settembre G. P., Agent Approach to Situation Assessment. *Proc. of 1st Int. Conf. on Agents and Artifical Intelligence* (ICAART '09), pp. 287–290, Porto, P, 2009.

[27] Rosati R., Effective ontology-based data integration. *Proc. of the 2009 Workshop on Ambient Data Integration*, volume 5872 of LNCS, Springer, Vilamoura, P, 2009.

PhD theses

[28] Marchetti L., *To believe or not to believe: Improving distributed data fusion with second order knowledge.* PhD thesis, Sapienza Università di Roma, 2009.

[29] Settembre G. P., *Multi-agent approach to situation assessment.* PhD thesis, Sapienza Università di Roma, 2009.

[30] Tipaldi G. D., *Looking inside for mapping the outside: Introspective Simultaneous localization and mapping.* PhD thesis, Sapienza Università di Roma, 2009.

Submitted papers, technical reports and others

[31] Almatelli A. and.Rosati R., Improving query answering over DL-Lite ontologies. *Proc. of the The 12th Int. Conf. on the Principles of Knowledge Representation and Reasoning* (KR '10), 2010, to appear.

[32] De Giacomo G. and Felli P., Agent composition synthesis based on atl. *Proc. of the 9th Int. Conf. on Autonomous Agents and Multiagent Systems* (AAMAS' 10), 2010, to appear.

[33] De Giacomo G., Lesperance Y. and Pearce A., Situation calculus-based programs for representing and reasoning about game structures. *Proc. of the The 12th Int. Conf. on the Principles of Knowledge Representation and Reasoning* (KR' 10), 2010, to appear.

[34] De Giacomo G., Patrizi F. and Sardina S., Agent programming via planning programs. *Proc. of the 9th Int. Conf. on Autonomous Agents and Multiagent Systems* (AAMAS '10), 2010, to appear.

[35] De Giacomo G., Patrizi F. and Sardina S., Generalized planning with loops under strong fairness constraints. *Proc. of the The 12th Int. Conf. on the Principles of Knowledge Representation and Reasoning* (KR '10), 2010, to appear.

[36] Liberatore P., Bijective Faithful Translations among Default Logics. Submitted.

[37] Motik B. and Rosati R., Reconciling Description Logics and Rules. Expected to appear in the *Journal of the ACM*.

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
- Data mining and universe selection problems
- Machine learning

Members: Carlo Mannino, Antonio Sassano (leader).

PhD Students: Carla Michini.

Post Docs: 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 design of sophisticated algorithmic tools to solve real-life problems. Originally the research was focussed on theoretical aspects of the stable set and set covering polytopes. At the same time, a whole line of research was devoted to the realization of effective solution algorithms for the associated optimization problems. As a natural extension, solution algorithms for coloring and frequency assignment problems were also studied. This last problem introduced the group to the more general wireless network design problem which has been a major research stream in the past years. Finally, new emerging topics concern data mining, supervised and unsupervised machine learning and job-shop scheduling applied to railway traffic management.

Main research results were obtained on the following 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 problems; 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 satisfaction of logic formula, algorithms for matching; efficient training algorithms for boosting and support vector machine for data classification and pattern recognition problems. In the last 10 years the group has developed methods and algorithms aimed at the optimal design of broadcasting networks. The scientific leadership gained in this field has motivated a stable cooperation with the Italian Authority for Telecommunication and

the decisive contribution of the group to the design of the national (analog and digital) TV and radio plans.

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; advanced optimization techniques for boosting problems in supervised machine learning problems; purely combinatorial approaches to wireless network design; railway traffic control and optimization on single-track networks.

Projects:

- *APICE - Algoritmi per la Pianificazione Integrata e Controllo di reti wireless Eterogenee* - January 2008, April 2010 - MIUR.

- *Metodi di ottimizzazione su larga scala nelle telecomunicazioni* - March 2010, March 2012 - MIUR, COFIN.

Journals

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Articles in books

[2] D'Andreagiovanni F. and Mannino C., An Optimization Model for WiMAX Network Planning. In Zhang Y., editor, *WiMAX Network Planning and Optimization*, Auerbach Publications, pp. 369–386, 2009.

Conference proceedings

[3] Bruni R., Using the Power of Formal Languages and SAT Solvers for effective Polymer Sequence Analysis (Extended abstract). *Proc. of the AIRO winter Int. Conf.*, Cortina, I, 2009.

[4] Bruni R., A Logic-based Approach to Peptide Sequencing. *Proc. of Bio-Logical 2009, workshop of the AI*IA 2009 Conf.*, Reggio Emilia, I, 2009.

[5] Mannino C. and Mascis A., Effective Lower Bound for Job-Shop scheduling in railway traffic control. *Proc. of the Int. Network Optimization Conference* (INOC), Pisa, I, 2009.

[6] Mannino M., Mattia S. and Sassano A., Planning Wireless Networks by Shortest Path *Proc. of the Int. Network Optimization Conf.* (INOC), Pisa, I, 2009.

Submitted papers, technical reports and others

[7] D'Andreagiovanni F., Mannino C. and Sassano A., A Power-Indexed formulation for Wireless Network Design Tech. Rep. no. 14/2009, Dipartimento di Informatica e Sistemistica, 2009.

[8] Bruni R., A Logic-Based Approach to Polymer Sequence Analysis. Expected to appear in the *Journal of Mathematical Modelling and Algorithms*.

[9] Mannino C., Mattia S. and Sassano A., Planning Wireless Networks by Shortest Path Computational Optimization and Applications Accepted for publication in *Computational Optimization and Applications* Springer.

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: Lorenzo Bergamini, Ugo Colesanti, Luca Filipponi.

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 thedesigner 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.

Journals

[1] Baldoni R., Beraldi R. and Noor Mian A., A survey of Service Discovery in Multihop Mobile Networks. *IEEE Pervasive computing*, 1:66–74, 2009.

[2] Baldoni R., Beraldi R. and Querzoni L., Low hitting time random walks in wireless networks. *Wireless Communications and Mobile Computing*, 9(5):719–732, Wiley, 2009.

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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.

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 methods 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:

- *Viewfinder - Vision and Chemiresistor Equipped Web-connected Finding Robots* - 2006, 2009 - EU FP7 Strep.

- *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.

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, Paolo Felli, Andrea Marrella, Matteo Di Gioia.

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:

- *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.

- *SemanticGov -Providing Integrated Public Services to Citizens at the National and Pan-European level with the use of Emerging Semantic Web Technologies* - January 2006, April 2009 - EU FP6.

- *INTEROP* - January 2004, December 2007 - EU FP6.

- *eG4M - eGovernment for Mediterranean Countries* - November 2005, April 2009 - MIUR FIRB.

- *ESTEEM* - January 2006, December 2007 - MIUR PRIN.

- *NEP4B* (Project managed by Università di Modena e Reggio Emilia) - 2006, 2009 - FIRB 2005.

- *TOCAI.IT - Tecnologie Orientate alla Conoscenza per Aggregazioni di Imprese in Internet* (Project managed by CINI - Consorzio Interuniversitario Nazionale per l'Informatica) - July 2006, April 2010 - MIUR.

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[2] Covino F. and Mecella M., Mesh-based P2P Live Video Streaming with StreamComplete. *Journal of Mobile and Multimedia*, 5(3):203–237, 2009.

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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: Silvia Bonomi, Adriano Cerocchi, Luca Montanari, Marco Platania, Hani Qusa.

Post Docs: Yann Busnel, Giorgia Lodi, Sirio Scipioni.

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:

- *RESIST, Resilience for Survivability* - January 2006, April 2009 - EU NoE.

- *SemanticGov, Providing Integrated Public Services to Citizens at the National and Pan-European level with the use of Emerging SemanticWeb Technologies* - January 2006, April 2009 - EU Strep.

- *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 .

- *EG4M, eGovernment for Mediterranean Countries* - January 2006, May 2009 - MIUR FIRB.

- *Progetto FIRB Italia Israele, Sapienza - Technion Haifa* - July 2006, July 2009 - MIUR FIRB .

- *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.

- *Ring p2p, Peer to Peer Telephony* - January 2009, January 2010 - Telecom Italia Spa TiLab.

- *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 (i) – Data Distribution in dynamic distributed Systems* (Project managed by CINI - Consorzio Interuniversitario Nazionale per l'Informatica) - January 2007, December 2009 - CINI-FINMECCANICA.

- *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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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, 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.

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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.

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:

- *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, Alessandro De Carli, 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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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, Alberto Nastasi, Pierfrancesco Reverberi.

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

Our research field includes general issues in industrial economics, with an emphasis on competition, regulation and investment in network industries. In particular, we analyze 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.

Regulation and competition in the pharmaceutical industry - We analyze the effects of different regimes of exhaustion of intellectual property rights on R&D firms' incentives to invest in product quality. National regulation gives rise to price differentials between countries that induce international arbitrage (Parallel Trade). Manufacturers may counteract using vertical price-squeeze or non-price discrimination. Our findings dilute theoretical and policy concerns about the effects of arbitrage on welfare.

Auction-based market mechanisms - We study how scarce resources can be traded via auction mechanisms. We focus on combinatorial auctions, which enhance the efficiency of market exchanges in presence of goods complementarity or substitutability. We also explore extensions of the Vickrey-Clarke-Groves (VCG) mechanism in combinatorial auctions. We show how the VCG rule can be exploited to measure some impacts which the formation of a coalition of bidders may have on the auction performance.

Supply chain management - We study the role of the exchange of structured data across information systems within inter-organization business processes. We assume that data are exchanged under given condition of quality and prices. We describe a brokering algorithm for obtaining data from peers, by minimizing the overall cost under quality requirements constraints.

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.

Our future work will focus on the interplay among competition, regulation, and investment in Next Generation Access networks (NGA). Regulatory policies have an impact on investment incentives. Different competitive scenarios may arise as a consequence of technology choices and

their impact on the scope for horizontal and vertical product differentiation. In particular we will analyse:

- The impact of the industry structure (vertical integration or separation) on investment incentives; 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.

- How a dominant firm may use mixed bundling of complements to extend market power from a monopoly primary market to a competitive complementary market. Bundling denies scale and reduces incentives to invest in quality for rival firms. We asses if a price test for detecting anticompetitive uses of bundling may improve welfare with respect to the alternative cases when bundling is banned or can be freely practiced.

- The development of different public-private partnership (PPP) models to finance investment in NGA deployment.

Projects:

- *INTERAGRO - metodi e strumenti per la supply chain INTEgRata nell'AGRO alimentare* - December 2005, December 2009 - MIUR FISR.

- *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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[2] Piccari P. L., Santori A. and Santori U., Leggere il Bilancio. *Il Sole 24 Ore*, 2009.

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[3] Avenali A., Matteucci G. and Reverberi P., How does vertical industry structure affect investment in infrastructure quality? *24th European Economic Assosiation* (EEA 2009) Barcelona, E, August 2009.

Submitted papers, technical reports and others

[4] Avenali A., Matteucci G. and Reverberi P., Dynamic access pricing and incentives to invest in alternative infrastructures. Accepted for publication in *Int. Journal of Industrial Organization*, 2009.

[5] Matteucci G. and Reverberi P. Parallel trade, quality investments and regulation. Submitted, 2009.

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 research of optimal policies for 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), Università Cattolica - Policlinico A. Gemelli (Roma), Istituto di Biologia e Patologia Molecolari - CNR (Roma), Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione INRAN (Roma), Istituto Superiore di Sanità (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 Sant et de la Recherche Medicale-Unité 870 Faculté de Medicine Lyon.

Projects:

- *Integrazione multimodale di dati EEG, MEG e fMRI per la stima dell'attività e connettività corticale nell'uomo* - February 2006, February 2008 - MIUR PRIN.

- *Studio, progetto e realizzazione di algoritmi efficienti di classificazione mediante reti neurali artificiali di immagini di provini metallografici di ghisa sferoidale; modelli dinamici basati su reti neurali artificiali di fenomeni di frattura* - January 2006, January 2008 - MIUR PRIN.

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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: 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:

- *PEEM: Post-earthquake emergency: Methods, Techniques and Support Instrumentation* - March 2004, December 2007 - Scientific Cooperation Italy-Japan, Italian Ministry of Foreign Affairs.

- *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.

PhD Students: Andrea Fiaschetti, Laura Fogliati, Guido Oddi, Laura Pimpinella, Filippo Rodriguez, Marco Veroli.

Post Docs: Marco Castrucci, Alessandro Di Giorgio, Silvano Mignanti, Antonio Pietrabissa, Vincenzo Suraci.

The networked systems area has developed, in the last 10 years, even thanks to the successful participation in 25 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:

- *Integrated Multiservice Architectures for Next Generation Services* - July 2004, June 2007 - Celtic IMAGES project.

- *Satellite-based communication systems using IPv6* - January 2006, December 2007 - European Union IST SATSIX Project.

- *P2P-Next, Next Generation Peer-to-Peer Content Delivery Platform* - January 2008, December 2011 - European Union ICT.

- *M3CAST, Multicast Multimedia Mobile Services* - March 2005, February 2009 - MUR Project.

- *APICE, Algorithms for Integrated Planning and Wireless network Control* - January 2007, June 2009 - MUR Project.

- *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.

- *WEIRD, WiMAX Extension to Isolated Research Data networks* (managed by CRAT - Consortium for the Research in Automation and Telecommunications) - June 2006, May 2008 - EU IST Project.

- *OMEGA, Home Gigabit Access* (managed by CRAT - Consortium for the Research in Automation and Telecommunications) - January 2008, December 2010 - EU ICT Project.

- *MICIE, Tool for Systemic Risk Analysis and Secure Mediation of Data Exchanged across Linked CI Information Infrastructures* (managed by CRAT - Consortium for the Research in Automation and Telecommunications) - September 2008, February 2011 - EU ICT Project.

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

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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. national and multilateral policies on foreign direct investment (FDI) and globalization.

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. Building on our previous analysis of firms' internationalization, we will deal with the effects of unilateral environmental

policies on firms' decision to relocate production abroad. 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.

Projects:

- *GARNET - Nerwork of Excellence on Global Governance, Regionalization and Regulation: The Role of the EU* (Project managed by CIDEI - Centro Interdipartimentale di Economia Internazionale) - June 2006, May 2010 - EU FP6.

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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, Antonio Franchi, Fabrizio Flacco, Paolo Stegagno.

Post Docs: Luigi Freda, Luca Marchetti, Pietro Peliti, Chiara Toglia.

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

The main research results were obtained on the following subjects: nonlinear control of robots with flexibility concentrated at the joints or distributed along the links; iterative learning of repetitive motion; hybrid force/velocity control of manipulators interacting with the environment; optimization schemes in kinematically redundant robots; motion planning, set-point regulation, and trajectory tracking for 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 locomotion platforms for VR immersion; image-based visual servoing; sensor-based navigation and exploration in unknown environments; randomized motion planning for high-dimensional systems in the presence of obstacles; multi-robot coordination and mutual localization.

The Laboratory is currently equipped with a 6R industrial robot (KUKA), an underactuated arm (Pendubot), a medium-size (Magellan) and a team of 5 small (Khepera-III) mobile robots, and 2 legged robots (Aibo), all endowed with a variety of ultrasonic and laser range finders, and (stereo)vision systems. In the past, we designed and built a two-link flexible manipulator (FlexArm) and a differentially-driven wheeled mobile robot (SuperMARIO).

In addition to the further development of on-going research projects, our future activities will also include the control of robots with variable impedance actuation, trajectory tracking and visual servoing for unmanned aerial vehicles (UAV), using a quadrotor as experimental set up, control-based motion planning for mobile manipulators, motion planning and control of humanoid robots, and sensory supervision of human-robot interaction. We shall also pursue some more applied research, including the navigation and coordination of a large team of mobile robots for luggage transport in airports and an autonomous GPS-guided line tracer for marking roads.

Projects:

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

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

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

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[15] De Luca A., Ernst M., Frissen I., Robuffo Giordano P. and Souman J., Making virtual walking real: Perceptual evaluation of a new treadmill control algorithm. Accepted for publication in *ACM Transactions on Applied Perception*, expected to appear in vol. 7(2), 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.

PhD Students: A. Di Giorgio.

Post Docs: Fabio Celani

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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[15] Isidori A., Marconi L. and Praly L., About the existence of locally Lipschitz output feedback stabilizers for nonlinear systems. *SIAM Journal on Control and Optimization*, 48(5): 3389–3402, 2010.

[16] Isidori A., Marconi L. and Praly L., Robust asymptotic stabilization of nonlinear systems with non-hyperbolic zero dynamics. Expected to appear in *IEEE Transactions on Automatic Control*.

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.

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