“The Institute of Intelligent Systems for Automation performs research, development and innovation activities in the area of intelligent agents both physical and software.”
In the next future robotics and Earth observation systems will be integrated with technologies for a smart and green society for the management of urban, rural and coastal systems as well as of natural and anthropic hazards. Multi- and inter-disciplinarity will be the key for new research approaches able to open the way to effective innovative products and services.

Dott. Massimo Caccia
Institute Director
The Institute is partner of different EC projects in the fields of Robotics, Earth observation, Spreading Excellence and Widening Participation, and Infrastructures.
Our Approach

ISSIA revisits the traditional background in image and signal processing, marine-maritime technology, and power electrical systems in a multi- and inter-disciplinary approach to the development of physical and software intelligent systems for monitoring of, understanding and interacting with complex and uncertain environments.

Research, mainly focused in the fields of robotics and automatica, technologies for Earth observation and smart communities, Factory of the future, green energy systems, smart cities and maritime technologies, spreads its areas of application from space to deep ocean, through land, coastal and city management.

ISSIA, thanks to its multi-territorial configuration with units in Bari, Genova and Palermo, is a natural connecting point between research and development strategies for Central Europe, Adriatic-Ionian and Mediterranean regions, and can play a key role for a synergic exploitation of different RD&I programs.
Our 5 Research Groups

EARTH OBSERVATION

Fabio Bovenga /
Received the laurea degree and the Ph.D. degree in physics from the University of Bari. His main research interests concern advanced processing techniques for Synthetic Aperture Radar (SAR) imaging and SAR interferometry and, the application of multi-temporal / multi-frequencies analysis to ground monitoring.

FIELD AND INTERACTION ROBOTICS

Gabriele Bruzzone /
Received the degree cum laude in electronic engineering. In the last 20 years he focused his research activity on design, development and test at field of autonomous robotic vehicles. He leaded numerous Research Projects and Scientific Campaigns also in Polar Regions.

TECHNOLOGIES FOR SMART COMMUNITIES

Cristiano Cervellera /
Ph.D. in electronic engineering and computer science. Research focused on computational intelligence methods for optimization and learning. Author of more than 80 works in various journals and conferences. Associate Editor for the IEEE Transactions on Neural Networks and Learning Systems.

SMART ENERGY CONVERSION

Marcello Pucci /
Has been a researcher with the CNR-ISTRA since 2001, where he is a senior researcher since 2008. He has been supervisor of 5 PhD thesis and 7 master thesis. He has authored more than 33 papers on ISI Journals, 72 papers in conferences, one book and 2 chapters of books.

SENSING, COMMUNICATION AND COMPUTATIONAL INTELLIGENCE

EttoRE Stella /
Interests are on computer vision and robotics area. He has been supervisor of several degree thesis and he is scientific head of several research projects. He is co-author of more than 100 papers on international journals, proceedings, book chapters and international patents.
Earth observation activities are devoted to develop algorithms for processing images from passive and active sensors acquired by satellites and aircrafts, and for retrieving bio-geophysical parameters at various spatial/temporal scales and resolutions.

During the past 30 years, ISSIA has been carrying out research activities on image analysis for Earth observation (EO). The ISSIA EO research unit, currently composed by 9 researchers, 5 assistant researchers, and 1 technical staff, has been and is involved in several projects funded by space agencies, national and international research institutions, as well by the European Commission.

EO activities are devoted to the development of physically based algorithms for processing and interpretation of multi-scale, multi-temporal, multi-frequency data, and for retrieving bio-geophysical parameters at various spatial/temporal scales and resolutions.

Images from both passive (VIS, NIR) and active (Synthetic Aperture Radar) sensors, and acquired by satellites as well as aircraft, are processed to support several applications. Moreover, in situ measurement infrastructures are also developed and exploited for monitoring the status of both soil and sea.

Four main research themes are currently active within the ISSIA EO unit:

- Retrieval of geo-physical parameters from EO data for land and sea applications (e.g. soil moisture content, vegetation biomass, wind direction, oil slicks)
- Multi-temporal SAR / InSAR for environmental hazard monitoring
- Development of advanced algorithms for the segmentation, classification, and multi-sensor/multi scale data fusion of EO data with application to the monitoring of land cover, biodiversity and habitats.
- Study of the oceanographic processes along the water column and at the air-sea interface, by means of the CNR infrastructure ODAS Italy 1 buoy, and the development of permanent measurement devices on autonomous and intelligent platforms for time series data collection.

The main application fields are in the following.

**Mitigation of natural and anthropogenic risks:**

- Monitoring of ground displacements (e.g. landslides, subsidence) by processing interferometric stacks of SAR satellite images.
- Flood monitoring by processing SAR/InSAR data
- Oils slick monitoring by processing both SAR and optical data

**Preservation of natural environment:**

- Generation of habitat / habitat change maps and biodiversity indicators by processing high resolution earth observation images
- Retrieval of sea wind fields and wave fields from SAR data, for monitoring sea pollution, coastal erosion, ...
- In situ monitoring of sea habitat

**Land monitoring for water and food security:**

- Monitoring agricultural and hydrological conditions of land surfaces (e.g. land use, LAI, vegetation biomass, soil moisture content) for improving water and crop management.

The team participates or leads scientific proposals and projects funded by international /national entities such as EU, ASI, ESA, DLR, JAXA, CSA, NASA, the Italian MIUR, and the Regione Puglia administration, on present / near future EO missions.
EARTH OBSERVATION
The Field and Interaction Robotics (FIR) research group has more than 20 years of experience in the area of robotics, carrying out theoretical and applied research, supported by the development and exploitation at field of unmanned vehicles.

The Group is composed of 8 researchers, 5 assistant researchers, 1 technologist, 4 technicians and it is/has been involved in manifold international and national research projects and scientific campaigns. The research program of the FIR group focuses on the following thematic areas:

1) Systems, Control and Decision: study and development of methodologies for the control of robotic platforms and development of hardware and software architectures for the realization of integrated systems composed of heterogeneous platforms;

2) Perception & Ambient Awareness: aggregation and composition of multi-sensorial data, acquired by heterogeneous platforms, in order to generate joint data models (e.g. composition of 3D video reconstructions with acoustic, chemical, biophysical data) for the ambient awareness of robotic vehicles operating in dynamic and unstructured environments;

3) Interaction, Synergy and Cooperation: study and development of methods for using robotic platforms as support and assistance for the human being, with the objectives of: i) contributing to the welfare of the human being; ii) performing tasks in hostile and hazardous environments; iii) carrying out repetitive, stressful, complex or impossible tasks to implement for the human being; iv) cooperating with the human being to perform specific tasks.

More in particular, the research deals with the study of robotic systems capable of acting autonomously in unstructured environments with a focus on sw/hw development platforms, control architectures, motion estimation systems, sensor-based guidance and control (both continuous-time and synchronous systems), systems for the control of the execution, coordination and mission control (both discrete-time and asynchronous systems), communication systems and protocols, IoT (Internet of Things). Of particular interest are the studies carried out in the field of cooperative/coordinate control of unmanned vehicles, the application of SLAM techniques based on optical vision, and identification, navigation, guidance, including anti-collision. All this research, having a theoretical-experimental nature, is supported by the development of mobile robotic platforms prototypes used also in marine and maritime environments, which have the typical features of an unstructured environment. Most of the autonomous robots developed by the FIR group were tested in real conditions for performing operations like monitoring and data collection in unstructured and/or dangerous/hostile environments (e.g. Polar regions).
FIELD AND
INTERACTION
ROBOTICS
Multidisciplinary research to support smart communities, performing different intelligent tasks such as learning, optimal control, energy efficiency. Possible applications include sustainable mobility, smart grids, internet of things, user behavior models, etc.

- modeling and simulation of nonlinear complex systems;
- computational intelligence models;
- data mining techniques;
- nonlinear control techniques;
- fault detection;
- distributed measurement systems;
- communication systems;
- predictive algorithms;
- optimization techniques.

Technological solutions for different application fields

- predictive models and optimal control for sustainable mobility;
- distributed measurement systems and intelligent devices for the control, monitoring and power quality of smart grids;
- data mining and computational intelligence tools for the characterization of social contexts and the optimization of policies of various nature (commercial, safety, etc.);
- Forecasting models of energy demand;
- optimization of logistic flows;
- optimization and energy efficiency of cloud infrastructures;
- real-time optimal control of energy flows in smart distribution networks with an increasing number of renewable sources;
- ICT technologies and model building to make the communication easier between citizens and public administration;
- structural and dynamic optimization of technological systems in smart buildings;
- diagnostics and optimization for energy chains of hybrid vehicles;
- real-time optimal resource allocation in intermodal terminals;
- power line communication for smart grids.

A smart community brings together cities, industry and citizens to improve the quality of urban life through more sustainable and integrated solutions. This includes, for example, applied innovation, better planning, a more participatory approach, higher energy efficiency, better transport solutions, and intelligent use of Information and Communication Technologies (ICT).

In spite of the heterogeneous nature of such contexts, the related applicative scenarios can be often formalized as highly complex nonlinear systems, with a large amount of data coming from sources of different nature that have to be managed and interpreted. The main objective of the research group is the development of algorithms and technologies to support the smart communities, performing different intelligent tasks such as learning, control, monitoring, predictive diagnostics, dynamic optimization and energy efficiency, that are needed in most applications, such as sustainable mobility, smart grids, cloud infrastructures, internet of things, service user behavior, decision processes.

Research methodologies

The research is multidisciplinary and rooted in the natural intersection of disciplines such as computational intelligence, automatic control, operations research and electronics engineering.
Energy conversion for low carbon generation and for electrical storage
Powertrains for green mobility and factory automation.
Microgrids for efficient use of energy in smart buildings and green vehicles

Smart energy conversion for low carbon generation and for electrical storage

• Static and dynamic models and parameter estimation (system identification) of:
  1) photovoltaic (PV) sources based on silicon or innovative materials;
  2) wind/marine current turbines, even in presence of ground/sea bottom effects;
  3) rotating and linear electric generators;
  4) storage systems (batteries, supercapacitors).
• Design and experimental prototyping of several typologies and topologies of electronic power converters with high dynamic performance and high efficiency for the interface between the smart micro-grid and the main power network, with renewables sources based generators and storage systems (batteries, supercapacitors).
• Design and experimental prototyping of rotating and linear electric machines for applications related to the renewables sources based power generation.
• Design, development and experimental implementation on embedded platforms of control and observations systems, by linear and non-linear techniques for renewables sources based power generation.
• Implementation and experimental validation of maximum power point tracking techniques (MPPTs), of both the P&O (Perturb and Observe) and neural type, for PV/wind/marine current generators.
• EMI reduction in power converters by means of active/passive filters and pulsewidth modulation (PWM) techniques.

Smart powertrains for green mobility and factory automation

• Design and experimental prototyping of several typologies and topologies of electronic power converters and electrical machines, both rotating and linear, for the propulsion and actuation systems in smart vehicles and factory automation.
• Design, development and experimental implementation on embedded platforms of control and observations systems, by linear and non-linear techniques for smart vehicles and factory automation.
• Innovative techniques and devices for Power Quality and the reduction of the EMI in electric drives.
• Electrical losses minimization techniques (ELMT) in electrical drives.

Smart microgrids for efficient use of energy in smart buildings and green vehicles

• Study DC distribution systems in smart micro-grids for applications in residential/commercial buildings as well as in smart vehicles, including ships.
• Data reconstruction and forecasting techniques of electric/meteo-climatic data for the forecasting of the electric energy production capability.
• Smart micro-grid modelling for applications in residential/commercial buildings as well as in smart vehicles, including ships.
• Development of energy management systems (EMS).

Application frameworks

• Low carbon technologies
• Smart factories
• Smart vehicles
• Smart grids
• Smart Buildings
• Smart Cities
Development of methodologies, technologies and systems for designing intelligent agents that can work autonomously or cooperate with human operators for making decisions in different fields of application.

Objective:
The objective of the project: "Sensing, Communication and Computational Intelligence" is to develop methodologies, technologies and systems for designing intelligent agents that, through the acquisition, transmission, processing, analysis and interpretation of multi-sensory data, can work autonomously or cooperate with human operators for making decisions in different fields of application.

The cultural framework of the project involves the following issues:

- Data Acquisition and Transmission: Design and development of multi-sensory systems and advanced technologies in contexts characterized by technological needs such as: inter-connectivity (wired or wireless), remote control, management of high flows of data, real-time storage of big data, data compression, Energy harvesting, energy management, etc.

- Data Fusion and Interpretation: Design and development of methodologies for processing and fusing multisource and multimodal data. Design and development of tools for the analysis of data, for the selection of features, for decision support systems.

- Decision Support: Design and development of methodologies (such as neural classifiers, Bayesian classifiers, SVM, Statistical classifiers, HMM, etc.) for decision support, for the development of HMI interfaces and intelligent systems that cooperate with the operators for decision and control problems.

- Performance Optimization: Development of methodological solutions in order to meet the real needs of the end users. Design and development of specialized implementations by using advanced technologies such as advanced HMI interfaces.

The application fields are numerous: diagnostics and quality control in transport, industry, aerospace, agro-food and health; autonomous navigation of mobile platforms; service robotics; surveillance and security; real-time monitoring of highly dynamic events; cultural heritage preservation and fruition; just to mention a few.

The group has also a deep knowledge in the field of ICT infrastructures, networking and network security. In more details:

- engineering and management of cloud-based and mission-critical network infrastructures;
- energy-aware optimization, including frequency control of host composing datacenters, migration of virtual machine and the impact of security mechanisms on the overall consumption;
- network security aspects, ranging from the hardening of production-quality setups to research activities in the field of information hiding.

- IoT, mobile computing/networking and smart-based services, especially applied to the access to and control of remote facilities (e.g., for manufacturing environments).
SENSING, COMMUNICATION AND COMPUTATIONAL INTELLIGENCE
3 Operating sites

63 Staff

35 Active Projects

4 Millions total funding

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