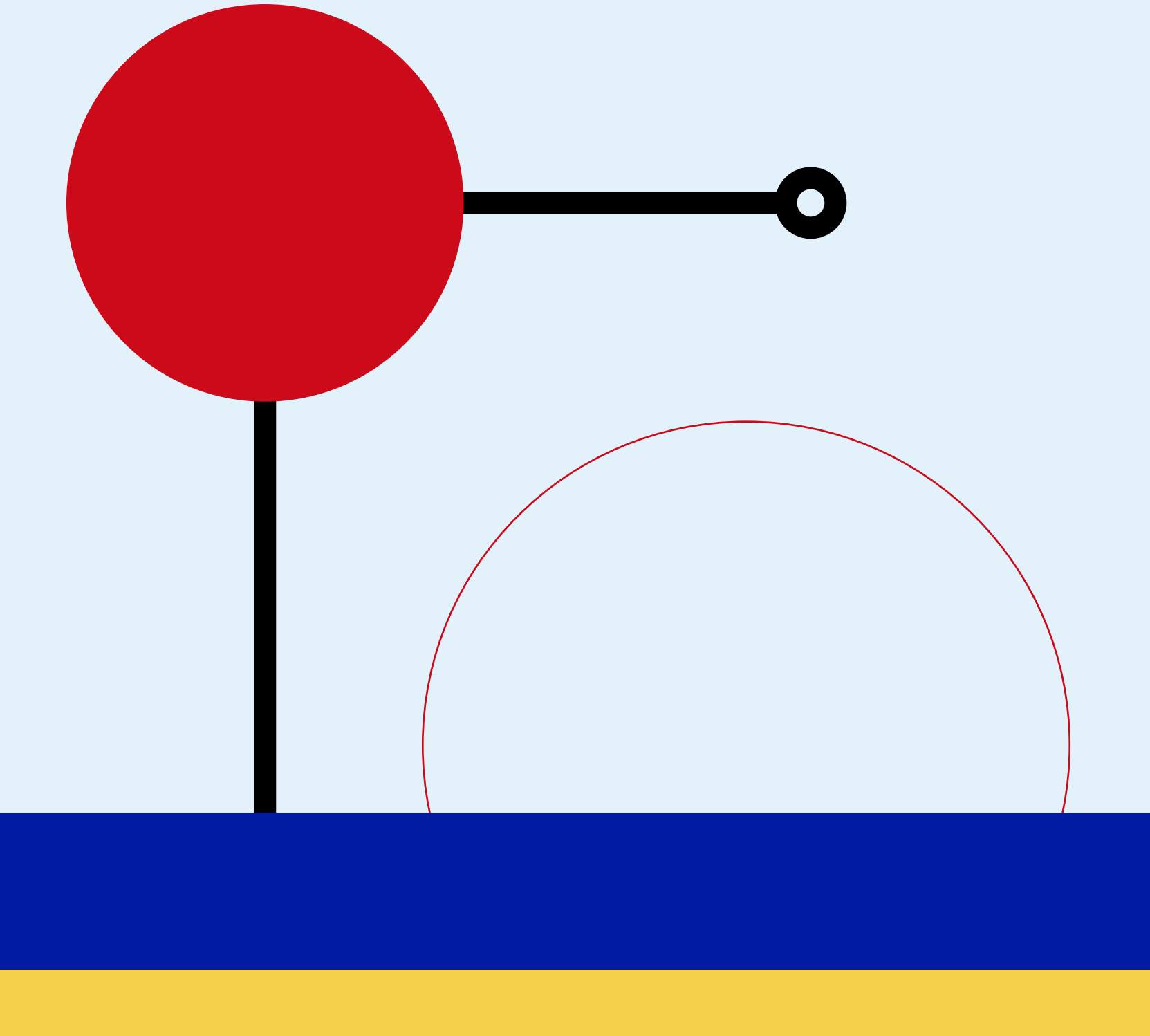
2021-2024

IRI REPORT

Institut de Robòtica i Informàtica Industrial

CSIC

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH



INDEX

WELCOME

Teniu a les mans la memòria de la recerca i activitats de l'IRI durant els últims quatre anys, un període que ha estat ple de reptes, però també d'oportunitats. Hem treballat intensament a posicionar l'IRI com un centre de referència a escala nacional i internacional. Durant aquest període hem incorporat vuit nous investigadors permanents, sis tècnics, i hem diversificat les fonts de finançament dels nostres projectes (Generalitat, Estat, diferents programes EU, Noruega, i Japó). Això ha comportat una millora en la qualitat i l'impacte de les nostres publicacions. Els nostres investigadors han incrementat els projectes amb aplicació industrial i han participat en la creació de dues empreses i tres accions de protecció del coneixement.

Hem deixat enrere la pandèmia i ens hem trobat amb una nova realitat on el teletreball s'ha imposat com una nova normalitat. Les noves llibertats ens permeten ser més flexibles, però ens obliguen a trobar noves iniciatives de motivació i cohesió del grup. En aquest sentit, iniciatives com ara els esdeveniments socials a l'estiu i per Nadal s'han reforçat, hem variat els objectius dels consells d'institut, i hem implicat al personal de l'IRI en diverses comissions amb composicions diverses.

Durant aquests quatre anys, l'equip de direcció i administració ha treballat intensament en un nou conveni entre el CSIC i la UPC que arriba finalment a bon port, i permetrà encarar el futur amb els rols de les dues entitats clars i reforçats per aconseguir sinergies que ens permetin créixer i aportar al nostre entorn encara més.

Estem immersos en les obres de LabORA que transformaran el nostre institut, amb més espais de recerca i cocreació. Aquesta iniciativa en permetrà impactar en l'ecosistema empresarial local, obrint la porta a noves oportunitats de col·laboració amb l'entorn assistencial (hospitals, residències, entorns de cures), la indústria i la societat.

Aquests darrers anys el boom de la intel·ligència artificial generativa ha impactat amb força a la nostra societat i també en la nostra realitat en recerca. Això ens permet encarar desafiaments que fins ara semblaven molt distants en robòtica. Però a la vegada, els reptes de competir amb els grans actors internacionals ens ha obligat a definir curosament la nostra estratègia. Les nostres línies d'investigació integren les darreres tècniques d'intel·ligència artificial amb els principis científics teòrics i un profund coneixement de la robòtica. Tot això es desenvolupa amb un enfocament centrat en l'ètica i la convivència entre humans i robots, en coherència amb les directrius i programes europeus.

L'IRI és un entorn de recerca privilegiat, que continua creixent. L'IRI contribueix en recerca d'impacte internacional sense oblidar el contacte amb la nostra realitat més propera.

From left to right: Júlia Borràs (Deputy Director), Guillem Alenyà (Director), Anaís Garrell (Academic Deputy Director)

You are holding in your hands the report of the IRI's research and activities over the last four years, a period that has been full of challenges, but also of opportunities. We have worked hard to position the IRI as a centre of reference at national and international level. During this period, we have incorporated eight new permanent researchers, six technicians, and we have diversified the sources of funding for our projects (Generalitat, State, different EU programmes, Norway, and Japan). This has led to an improvement in the quality and impact of our publications. Our researchers have increased the number of projects with industrial applications and have participated in the creation of two companies and three knowledge protection actions.

We have left the pandemic behind and we have found ourselves in a new reality where teleworking has become the new normality. The new freedoms allow us to be more flexible, but force us to find new initiatives for motivation and group cohesion. In this sense, initiatives such as the social events in summer and at Christmas have been reinforced, we have varied the objectives of the institute councils, and we have involved the IRI staff in various commissions with different compositions.

During these four years, the management and administration team has worked intensively on a new agreement between the CSIC and the UPC that has finally come to fruition, and will allow us to face the future with the roles of the two entities clear and reinforced in order to achieve synergies that will allow us to grow and contribute even more to our environment.

We are immersed in the LabORA works that will transform our institute, with more research and co-creation spaces. This initiative will have an impact on the local entrepreneurial ecosystem, opening the door to new opportunities for collaboration with the care environment (hospitals, nursing homes, care settings), industry and society.

In recent years, the boom in generative artificial intelligence has had a strong impact on our society and also on our research reality. This allows us to face challenges that until now seemed very distant in robotics. But at the same time, the challenges of competing with the big international players have forced us to carefully define our strategy. Our research lines integrate the latest artificial intelligence techniques with theoretical scientific principles and a deep understanding of robotics. All this is developed with a focus on ethics and coexistence between humans and robots, in coherence with European guidelines and programmes.

The IRI is a privileged research environment, which continues to grow. The IRI contributes to research of international impact without forgetting the contact with our closest reality.

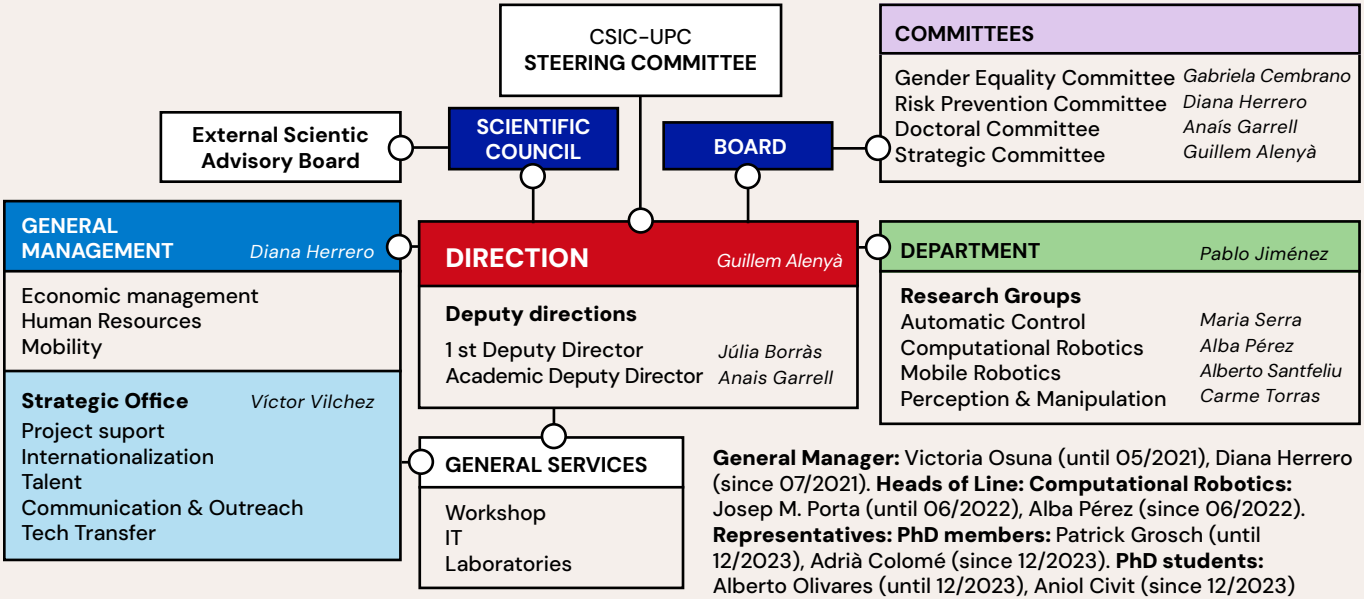
01 OVERVIEW

1.1 ORGANIZATION

The **Institut de Robòtica i Informàtica Industrial** is a Joint University Research Institute of the Spanish Council for Scientific Research (CSIC) and the Technical University of Catalonia (UPC).

The Institute conducts basic and applied research in robotics and automatic control. It was created in November 1995 and is located in the Parc Tecnològic de Barcelona, in the Faculty of Mathematics and Statistics and the Industrial Engineering School in the South Campus of UPC in Barcelona, Spain.

ADDRESS: C/ Llorens i Artigas 4-6. 08028 Barcelona, Spain



General Manager: Victoria Osuna (until 05/2021), Diana Herrero (since 07/2021). **Heads of Line: Computational Robotics:** Josep M. Porta (until 06/2022), Alba Pérez (since 06/2022). **Representatives: PhD members:** Patrick Grosch (until 12/2023), Adrià Colomé (since 12/2023). **PhD students:** Alberto Olivares (until 12/2023), Aniol Civit (since 12/2023)

Illustration: Organization in 2025.

COMMITTEES

The IRI Board has designated independent committees that work and give account on various themes.

GENDER EQUALITY COMMITTEE

This committee aims at fostering initiatives to improve women participation in robotics and control, both internally in our institute and in our education system and society. Its current **members**:
Gabriela Cembrano (coordinator), Antonio Andriella, Anaís Garrell, Alejandro López and Joan Vallvé. You can find more information in Section 1.6 of this report.

OCCUPATIONAL HEALTH AND SAFETY COMMITTEE

The objective of this committee is to improve health and safety in the workplace. Its **members**:
Diana Herrero (coordinator), Eduardo Ballesteros, Ferran Cortés, Sergi Foix, Sergi Hernández.

DOCTORAL COMMITTEE

This committee is in charge of monitoring the progress of IRI doctoral students, and is composed of these **members**:
Juan Andrade, Gabriela Cembrano, Mariella Dimiccoli.

STRATEGIC COMMITTEE

This committee oversees the implementation and assessment of the IRI Strategic Plan. Its **members**:
Guillem Alenyà, Diana Herrero, Sergi Hernández, Pablo Jiménez.

SUSTAINABILITY COMMITTEE

This committee promotes policies and actions related to sustainability practices such as those related to mobility or resource consumption.
Its **members**: Adrià Colomé, Giorgio Barbato, Roger Gallart and Mar Serre.

EXTERNAL SCIENTIFIC ADVISORY BOARD

IRI has an External Scientific Advisory Board (SAB) responsible for evaluating our strategic research program, as well as providing supervision and scientific guidance. This board is formed by these four internationally recognized scientists **members**:

- Prof. Alin Albu-Schäffer, German Aerospace Center, Germany, SAB President
- Prof. Chris Melhuish, Bristol Robotics Lab, Univ of the West of England, UK
- Prof. Cesare Alippi, Politecnico de Milano, Italy
- Prof. Tomás Lozano-Pérez, MIT, USA

RESEARCH GROUPS

The Institute's research activities are organized in four research lines:

AUTOMATIC CONTROL

From left to right:

Top row: *Mingrui Chen, Pol Baldomà, Carlos Ocampo, student, Joaquim Blesa, student, student, Vicenç Puig, Shuang Zhang, student, Pau Segovia, Mateo Arcila, Pol Cardona, Bryan Escachx, Miquel Martí*

Bottom row: *Ali Molavi, Gabriela Cembrano, Maria Serra, Ce Xu, Andreu Cecilia, student, student, Juan P. Martínez, Thomas Puleston, student*

COMPUTATIONAL ROBOTICS

From left to right: *Vicente Ruiz, Alba Pérez, Federico Thomas, Enric Celaya, Lluis Ros, Siro Moreno, Miquel Casadó, Sergi Pujol, Jaume Franch, Eduard Godayol, Ernest Arranz*

MOBILE ROBOTICS

From left to right:

Top row: *Alberto Sanfeliu, Ana Puig-Pey, Tibi Robot, Àngel Santamaria, Marc Dalmasso, Óscar Gil, Carlos Pérez, José Enrique Domínguez, Iván Del Pino, Anaís Garrell, Juan Andrade, Cristina Benlliure, Yi Tan, Sergi Hernández, Fernando Herrero, Niko Picello and Oriol Martínez*

Bottom row: *Lavinia Hriscu, Hafsa Taher, Ivo Robot, Antoni Salom, Hugo Duarte and Francisco Cristóbal García*

PERCEPTION AND MANIPULATION

From left to right:

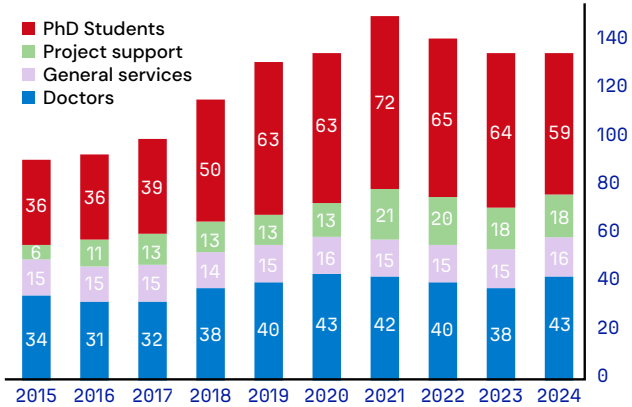
Top row: *Georgios Tzelepis, Franco Coltraro, Joan Omedes, Elena Bueno, Michele Patero, Marc Gutiérrez, Irene García, Cristian Barrué, Antonio Andriella, Guillem González, Jaume Oriol LLadó, Júlia Pareto, Antonio Martínez, Azra Aryania, Luca Lach, Roger Gallart, Edoardo Caldarelli, David Blanco, Alberto Olivares, Pablo Salido, Sergi Foix*

Bottom row: *Socrates robot, Mariella Dimiccoli, Adrià Colomé, Stretch robot, Pablo Jiménez, Carme Torras, Guillem Alenyà, Borrissol robot, Júlia Borràs, Clothi robot*

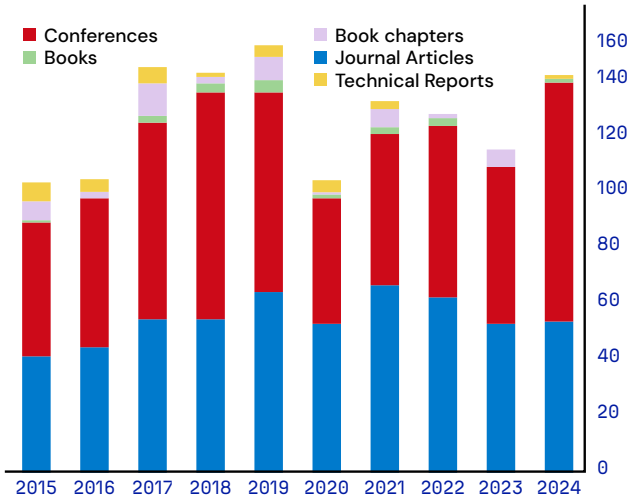
1.2 IRI IN NUMBERS

STAFF EVOLUTION

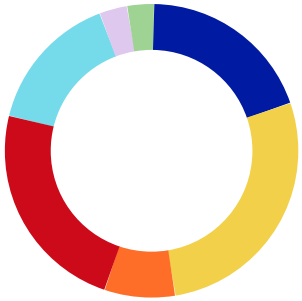
STAFF



PUBLICATIONS

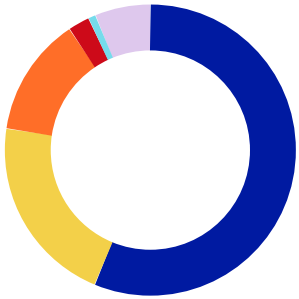


NUMBER OF COMPETITIVE R&D PROJECTS



European 13
National 18
Regional 5
CSIC 15
UPC 10
Foundations 2
Local 2

RECEIVED COMPETITIVE FUNDS



European projects 55,95%
National projects 21,03%
Regional projects 13,52%
Projects funded by CSIC 2,36%
Projects funded by UPC 0,62%
Others (local, foundations) 6,53%

43 Permanent Research Staff and Post

59 PhD Students

18 Support and Technical Staff

56 Undergraduate and Master Students

16 Service Staff

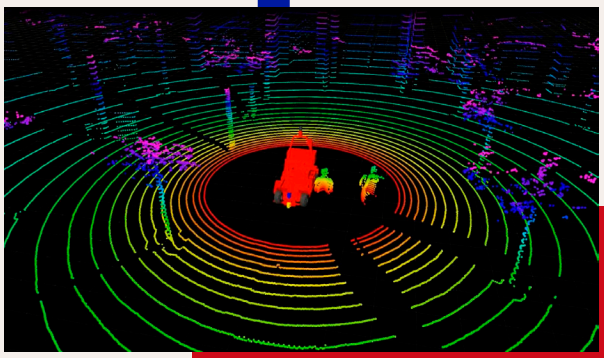
25 Robots

TOTAL during 2024: 192 people

1.3 FACILITIES

NEW FACILITY: LABORA

LabORA is the Open Laboratory for Assistive Robotics, an initiative that seeks to bring together and promote efforts in the field of assistive robotics. With the aim of developing technologies that improve people's quality of life, LabORA creates a space for collaboration between academic research, industry, the care sector, the administration and users to identify needs, develop technology and test robotic solutions in real environments. This will be the first time that the different actors involved in the promotion of healthcare robotics will work together in the same infrastructure. LabORA wants to contribute to the creation of a business network around this new sector, while promoting the necessary legislation.
More information at *labora.cat*.

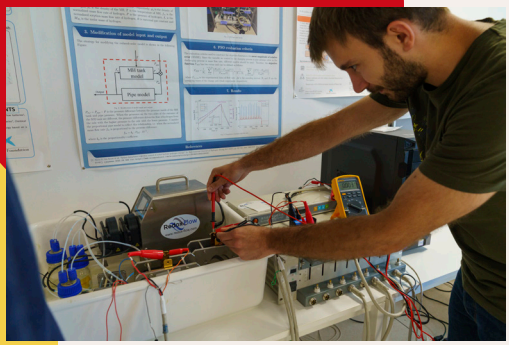


BARCELONA ROBOT LABORATORY

Located at the UPC Campus Nord, the Barcelona Robot Lab spans a 10,000-square-meter outdoor pedestrian area. It is equipped with 21 fixed cameras, a variety of robots, full Wi-Fi, mobile wireless connectivity, and partial GPS coverage. The lab processes imagery and sensor data in real-time to support robotic applications, and it serves as a research facility for urban pedestrian robotics in both national and European projects. It was established with support from the European TERRINET project and the national BRUL project.

COMPUTATIONAL ROBOTICS LABORATORY

The Computational Robotics lab was created to investigate the computational and implementation aspects that arise in the design, construction, and control of complex robotic systems. Among these systems we find serial, parallel, or locomotive robots, intelligent prostheses, biomechanical support systems for movement or rehabilitation, or other robots that, due to their sensory and compliance capacities, can safely interact with humans in an agile manner. The activity of the lab focuses on the analysis and construction of robotic prototypes to validate new algorithms related, but not limited to, positional and singularity analysis, workspace determination, collision detection, forward and inverse kinematics or dynamics, singularity-robust navigation, or planning and optimal control of robot trajectories.



CONTROL SYSTEMS LABORATORY

The Control Systems Lab is dedicated to the testing and validation of modelling and control strategies for dynamic systems in industrial and engineering applications. The lab provides an experimental platform equipped with pressure, flow, and level process systems, enabling the implementation and real-time evaluation of advanced control strategies. Beyond its original focus on water-cycle-related processes, the lab serves as a versatile environment for studying general process control principles, including system identification, control architecture design, and optimization-based control. The research conducted here extends to various domains, such as industrial automation, energy systems, and large-scale distributed control.

Additionally, the lab is open to collaboration, offering its facilities and expertise to other research teams in the scientific and engineering communities, fostering interdisciplinary advancements in automatic control.

FUEL CELL CONTROL LABORATORY

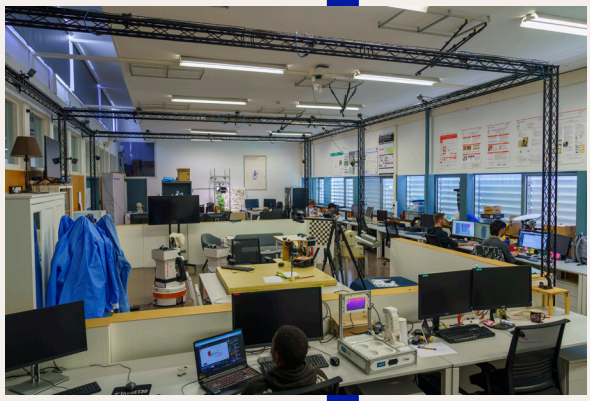
This Laboratory is used to test and validate controllers for fuel cell-based systems, hydrogen systems and other electro-chemical devices used for energy storage. The laboratory has five test stations, provided with oxygen, hydrogen, nitrogen and synthetic air. Depending on the type of experiment, each station is designed with a specific functionality. Test station 1 is used to characterize simple single cells as well as low and medium-power fuel cell stacks. Test station 2 is based on a 1200 watts fuel cell and is used for the connection of different electrical converters and energy storage systems to validate different control strategies and different levels of hybridization. The 3rd test station utilizes an environmental chamber as its main element, which controls relative humidity, temperature and oxygen concentration. Built on a vertical panel, test station 4 has all the components of a standard automotive system based on fuel cells. The fifth station contains an electrolyzer, a fuel cell stack and metal hydride hydrogen storage tanks, in a flexible configuration.

MOBILE ROBOTICS LABORATORY

The Mobile Robotics Laboratory is dedicated to hands-on research with mobile robotic devices. It features two service robots for urban robotics research based on Segway platforms (named Tibi and Dabo), a TIAGo Pro robot from PAL Robotics, a dual-arm mobile manipulator custom-built by PAL Robotics (named IVO), a four-wheel outdoor mobile robot, and three aerial autonomous robots with payload capacities ranging from 500 grams to 5 kilograms. The lab also includes several custom-made platforms for agile robotics research, along with numerous smaller robots, sensors, and cameras. Additionally, it has a 7x15-meter aerial test area equipped with a 20-IR-camera Optitrack positioning system.

PERCEPTION AND MANIPULATION LABORATORY

The Perception and Manipulation Laboratory is the facility devoted to experimentation on the topics of the research line. It occupies 142 m² in the second floor of the FME building, and a large part hosts a life-scale mock-up of a small apartment (35 m²). Two PAL one-armed mobile TIAGo robots dwell within the apartment, but are occasionally taken out for experimentation elsewhere. There is also a manipulation area equipped with two WAM robot arms and a KINOVA manipulator, and workplaces are distributed along the perimeter. Next to the laboratory, with a direct view through a window, there is the Scientific and Technical Lab support office. The Laboratory is further equipped with commercial and self-developed grippers, sensing devices, and augmented reality systems. Laboratory service offers quick experimental setup, several standardized software tools, and expertise in robot control and perception algorithms. It also hosted the Humanoids Lab Initiative in the past, and we still keep 15 small humanoid robots for educational or promotional purposes.



1.4 SUSTAINABLE DEVELOPMENT GOALS

Alignment with the **2030 Sustainable Development Goals:** IRI research strategy is being developed having the Agenda 2030 in mind. In particular, it is related to the next following sustainable development goals:

HORIZON EUROPE 2021-2027

- **1. HEALTH:** Areas of intervention: Tools, technologies and digital solutions for health and care.
- **2. CIVIL SECURITY FOR SOCIETY:** Disaster-resilient societies.
- **3. DIGITAL, INDUSTRY AND SPACE:** Artificial Intelligence and robotics. Advanced computing and Big Data.
- **4. CLIMATE, ENERGY AND MOBILITY:** Energy supply and storage. Clean, safe and accessible transport and mobility.
- **5. FOOD SYSTEMS:** Food, Bioeconomy, Natural Resources, Agriculture and Environment.

Regarding the Spanish Strategy for Science, Technology and Innovation 2021-2027 we are directly related to:

- **4.1 ARTIFICIAL INTELLIGENCE AND ROBOTICS.**
- **4.3 MODELLING AND MATHEMATICAL ANALYSIS** to provide solutions for science and technology.

1.5 SERVICES

TECHNICAL-ADMINISTRATIVE SUPPORT UNIT

From left to right:

Top row: *Luz Alberola, Carme Fernández, Patricia Rodrigo, Víctor Vílchez, Eduardo Ballesteros, Andoni Vitales, Ferran Cortés*

Bottom row: *Mar Serre, Diana Herrero, Ricard Ros, Patrick Grosch, Jose Luis Roncero*

The IRI's technical-administrative support unit is a dynamic, multi-professional team that coordinates efforts with the research groups, pursuing the common goal of excellence. This unit is made up of several areas of activity involved in a wide range of management and administration processes of all human, physical and financial resources, both internal and external.

Staff: *Diana Herrero (General Manager) (since 07/2021), Eduardo Ballesteros, César González, Ricard Ros (since 10/2023), Carme Fernández, Mar Serre, Andoni Vitales, Luz Alberola, Neus Salleras, Victoria Osuna (until 05/21)*

MECHATRONICS WORKSHOP

The Workshop provides support in the design, construction, and maintenance of electric, electronic, and mechanical devices and prototypes for the research projects carried out at IRI, as well as a warehouse of spare parts and materials. Current rapid prototyping equipment at the Workshop includes laser cutter for organic materials (CO2), laser cutter for metallic materials (fiber), 3D plastic printers and an electronic design workbench.

Staff: *Ferran Cortés, Patrick Grosch*

IT SERVICE STAFF

The IRI IT service (IRITIC) is responsible for all the computer and communications infrastructure of the Institute, as well as user support. We have a small data center properly suited with rack servers and communications devices.

Staff: *José Lázaro, José Luis Roncero*

STRATEGIC OFFICE

The Strategic Office is responsible for IRI's institutional communication, internationalization, talent and technology transfer efforts. It manages dissemination and outreach activities, including press releases, liaises with the media, manages social networks, organises institutional events and oversees the development and implementation of the corporate communication. The office is also in charge of the international projects and networking, negotiation and management of technology transfer agreements and initiatives with industry.

Staff: *Víctor Vílchez, Giorgio Barbato (since 11/2024), Patricia Rodrigo (since 04/2024)*

1.6 GENDER EQUALITY COMMITTEE

The team, formed by Gabriela Cembrano (coordinator), Antonio Andriella, Anaís Garrell, Alejandro López and Joan Vallvé, aims at fostering initiatives to improve women participation in robotics and control, both internally in our institute and in our education system and society.

You can reach the committee by mail at *igualtat@iri.upc.edu*

During the 2021-2024 period, the gender equality committee carried out the following initiatives:

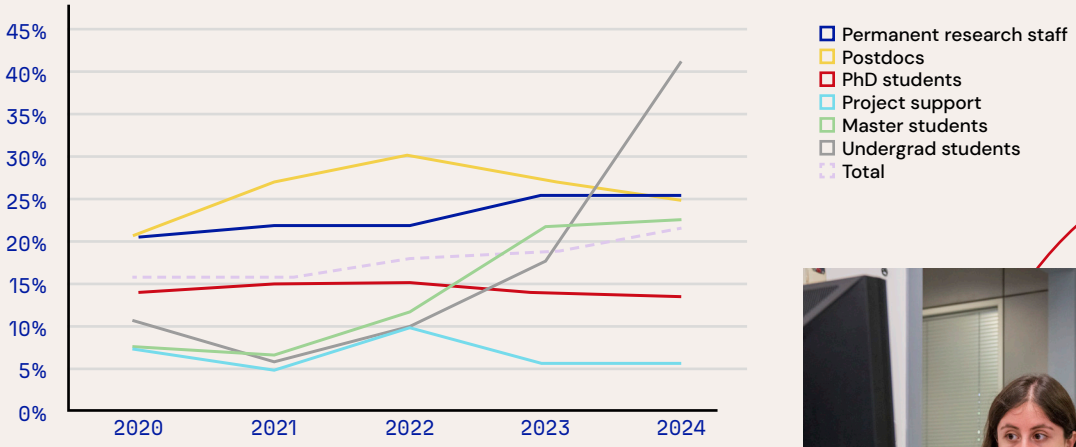
Video to commemorate the International Day of Women and Girls in Science 2023 "Robòtica i automàtica: Cosa de dones"

#1000raonsUPC Painting in the framework of the International Women's Day, March 8, 2023

The IRI Gender Equality Survey 2021 report

The next diagram shows the gender diversity at IRI between 2020 and 2024. The data indicates an increase in undergrad students. However, in areas such as permanent research staff, postdocs, project support, PhD and master students, gender representation has remained relatively stable or shown slight variability, suggesting that these areas may benefit from additional efforts to enhance diversity.

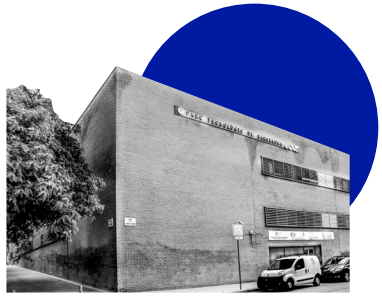
PERCENTAGE OF WOMEN



1.7 IRI'S HISTORY

2ND IRI DIRECTOR: FEDERICO THOMAS (2006 - 2008)
IRI is restructured into one single department, with four research groups: Automatic Control, Kinematics and Robot Design, Mobile Robotics and Perception and Manipulation.

2006



2005

Best PhD Award, Euron Georges Giralt (Juan Andrade).

2004

Agreement for the expansion of the IRI premises in the Barcelona Science and Technology Park is signed.

2011

Accounts are open on Social Media.

1995

1ST IRI DIRECTOR: RAFAEL HUBER (1995 - 2006)
Founding agreement is signed between the president of CSIC and the rector of the UPC.

1996

IRI officially begins its activity in the Nexus building with three research groups: Automatic Control, Robotics and Computer Graphics.

2006 - 2010

2011
2015

2001 - 2005

1995
2000

2001

Inauguration of the Barcelona Technology Park.

Best Robotics PhD Award of GTRob CEA-IFAC (Oriol Bo- higas).

2008

3RD IRI DIRECTOR: ALBERTO SANFELIU (2008 - 2014)
IRI becomes a Joint University Research Institute CSIC-UPC.

2013

2014

4TH IRI DIRECTOR: JUAN ANDRADE
(2014 - 2020)

2000

Agreement for the new location of IRI in the Barcelona Technology Park.

Carme Torras achieves ERC Advanced Grant for her project CLOTHILDE.

IRI is recognized as a María de Maeztu Excellence Unit 2017/2021.

Best Spanish thesis in Control Engineering, CEA Springer (Julián Barreiro).

Francesc Moreno wins the Google Faculty Research award.

EXCELENCIA MARÍA DE MAEZTU 07/2017-06/2021

2015

IRI 20th anniversary.

2017

2016 - 2020

Antonio Andriella wins Georges Giralt award

UPC Doctoral Special Award 2024: by Soheil Sarabandi and by Yashan Xing

ELLIS Barcelona will be codirected by Carme Torras (IRI) and Dimosthenis Karatzas (CVC)

2023

Celebration of the 25th anniversary

Start of the "AIHUB Connection" network of centres coordinated by Carme Torras (IRI) and Carles Sierra (IIIA).

UPC creates CER-H2, the specific center for Hydrogen Research

2021

datisión

2019

IRI launchs its first spin-off: DATISION.

Best PhD Thesis Award in Control Engineering, Spanish Automation (Ye Wang).

2018

IRI receives TECNIO accreditation.

Best PhD Thesis Award in Robotics GTRob (Adrià Colomé).

ISA Transactions Best Paper Award (Julián Barreiro and Carlos Ocampo).

IRI@ERL team winner of ERL competitions.

2020

Carme Torras receives the National Research Award "Julio Rey Pastor" from the Spanish Government and the Premi Nacional de Recerca by the Catalan Government.

Best PhD Thesis Award in AI, Marc Esteva Vivanco prize (Gerard Canal).

5TH IRI DIRECTOR: GUILLEM ALENYÀ (SINCE 2020).

2022

CSIC president (Eloísa del Pino), CSIC Vicepresident (Javier Moreno) and CSIC Catalonia Delegate (Lluís Calvo) visit IRI

BALL is presented: the first Living Lab focused on aging

2024

Franco Coltraro won the IEC Sant Jordi Award

ASPIRA-MaX Josefa Barba Award of Excellence.

LabORA works on the building

Carme Torras, Creu Sant Jordi Award 2024

New IRI Logo

RESEARCH 02

2.1 RESEARCH LINES

PERCEPTION AND MANIPULATION GROUP

The research of Perception and Manipulation Group focuses on enhancing the perception, learning, and planning capabilities of robots to achieve higher degrees of autonomy and user-friendliness during everyday manipulation tasks. Some topics addressed are the geometric interpretation of perceptual information, construction of 3D object models, action selection and planning, reinforcement learning, and teaching by demonstration.

Research areas:

Manipulation of deformable objects

- **Cloth reconstruction from images/video:** We specialize in classical computer vision algorithms, machine learning, and computer graphics to create advanced applications in 3D segmentation and cloth reconstruction.
- **Cloth simulation and representation:** We are interested in the modeling of textiles for simulations and in finding compact representations to enable reasoning in order to navigate its configuration space.
- **Skill learning:** We are interested in developing manipulation skills that include contact-righ interactions and deformable object manipulations
- **Variable Impedance control:** We develop intrinsically safe controllers, allowing our robots to safely collide with the environment in a soft and compliant manner.
- **End-effector design:** We design end-effectors to provide versatility and fine dexterous manipulation skills for unsolved manipulation challenges related to cloth manipulation and agriculture.
- **Benchmarking:** We are committed to building a community around manipulation of deformables with general metrics, benchmarks, competitions and fair comparison frameworks.

Assistive robotics

HUMAN-ROBOT INTERACTION

- **Personalization:** We investigate methods of personalization to adapt our robots to the particularities of each patient but also be adaptable by caregivers/doctors.
- **Understanding actions and interactions from videos:** We develop methods that efficiently address a wide range of video understanding tasks, while requiring minimal or no labelling cost.
- **Body pose and shape estimation:** We are interested in 3D vision methods including neural rendering for high-quality body and face reconstruction and vision-language models (VLMs) for assistive visual navigation.
- **Safe physical interaction:** We treat safety from the point of view of both the robot execution through compliant controllers and the trustworthiness of the different AI methods involved in our HRI demos.
- **Decision-making and planning:** We are interested in high-level task formulations integrated with low-level geometry-based methods and simplified physical models, together with an on-line sensory-based treatment of uncertainty.

EXPLAINABILITY:

We are fully committed to build trustworthy systems that guarantee self-explainability in all the different AI layers of software in an assistive robotic solution.

ROBOT ETHICS:

We are experts in robot ethics and its application in the context of assistive technologies.

Other topics and applications

- **Ontologies in different domains (industrial, HRI, manipulation...)** We are interested in novel knowledge representations in the different domains of application of our group.

- **Robotic solutions for agriculture applications.** We are interested in agricultural robotic solutions that assist in harvesting or plant inspection and require the manipulation of deformable objects like plants, flowers or delicate fruits.

MOBILE ROBOTICS AND INTELLIGENT SYSTEMS GROUP

The Mobile Robotics and Intelligent Systems Group focuses on equipping mobile robots and ubiquitous computing devices with the skills needed to assist humans in everyday activities. Recently, the group has concentrated on developing solutions for social robotics, robotic autonomy, and agile robotics. They participate in both international and national projects, covering areas such as social robotics, human-robot interaction, last-mile robotic autonomy, aerial robotics, agricultural robotics, event-based vision, care robotics, robotic infrastructure and networking, and robotic search and rescue.

Additionally, the group has contributed to the private sector by providing solutions for autonomous robotics in last-mile delivery, autonomous transport of goods for the automotive industry, and energy-efficient adaptive cruise control systems.

Research areas:

Social robotics

The group's work in social robotics focuses on human-robot and human-avatar interaction and collaboration. We develop techniques to predict and learn human behavior, facilitate human-robot task collaboration, and create empathetic robot behaviors using a variety of sensors, computer vision, and cognitive system technologies.

Robotic autonomy

The group also focuses on designing and developing mobile service robots for human assistance and interaction. Our research includes innovative hardware and software solutions for urban robotic services such as surveillance, exploration, transportation, last-mile delivery, human tracking, assistance, and guiding.

Robotic agility

We conduct research on hybrid agile locomotion and manipulation that combines flight and contact-based movements. Our work aims to understand, generate, and execute fast, agile hybrid robotic motions. To achieve this, we develop specialized hardware and software solutions for robotic perception, identification, estimation, and control, with an emphasis on autonomous learning.

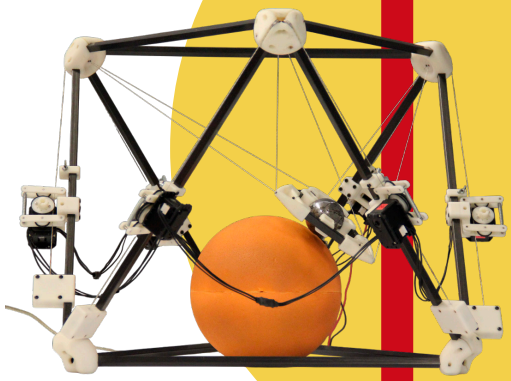
COMPUTATIONAL ROBOTICS

The Computational Robotics Group investigates the theoretical, computational, and implementation aspects that arise in the design, construction, motion planning, and control of complex robotic systems. Among these we find serial, parallel, or locomotive robots, intelligent prostheses, biomechanical support systems for movement or rehabilitation, or other robots that, due to their sensory and compliance capacities, can safely interact with humans in an agile manner.

Research areas:

Robot design and construction

The group designs and constructs innovative mechatronic devices based mainly on parallel architectures. Our developments include the "Wrenchpad" (a six-axis tactile pad), several tensegrity-based robots, a pentaglide, several variations of the Gough-Stewart platform, different cable-driven robots, and the "Scherbot" robot (a five-bar mechanism to test kinodynamic motion planning and control techniques to cross singularities). The group also works on the development of various reconfigurable robots. These offer the possibility of reducing the number of actuators needed to perform a task, with the consequent decrease in construction costs. Moreover, reconfigurations can also be used to enlarge the robot's workspace, or to avoid problematic configurations like singularities.

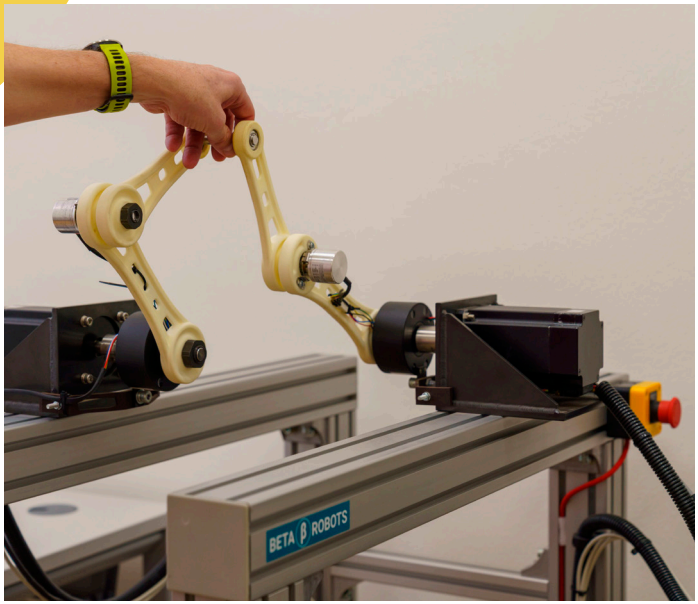


Computational kinematics and dynamics

The group develops novel methods for position analysis of multibody systems, aiming to find all feasible configurations under joint constraints. Applications include robotics (direct/inverse kinematics, cooperative manipulation, grasping, motion planning), structural biology (biomolecular conformations), and multibody dynamics (initial position or finite displacement problems). Two main approaches are used: relaxation techniques and characteristic polynomials via Distance Geometry. Many results are implemented in the CUIK suite, a toolbox for motion analysis of closed-chain systems. The group also has expertise in dynamics algorithms based on Clifford or Spatial Vector algebras, and in simulating constrained systems using integration on manifolds.

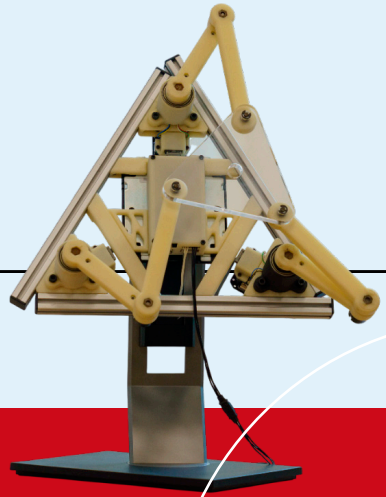
Singularity analysis

Singularities play a prominent role for understanding a robot's configuration space. They can cause overspeeding, dexterity loss, or controllability issues, and are usually avoided in sensitive applications like human-robot interaction. However, they can also offer mechanical advantages and define workspace boundaries, useful for robot design. The group develops geometric and computational tools to characterize singularity loci in specific robot classes and general multibody systems. It has also created algorithms to control motion across forward singularities, enabling an extended reachable workspace in parallel mechanisms.



Motion planning and control

Development of algorithms for planning and control of motions in general multibody systems with holonomic or nonholonomic constraints (e.g., loop-closure, contact, or rolling). The aim is to generate feasible, collision-free trajectories and robust controllers for accurate tracking. Techniques consider both kinematic constraints and full dynamic models, including motor limits. Motion planning combines higher-dimensional continuation and randomized sampling, refined by trajectory optimization. Control is achieved using numerical optimal control. These methods are applied to fixed-base manipulators, mobile robots (omnidirectional, nonholonomic, inverted pendulum), cable-driven systems, and drones. The group also explores related problems in biochemistry, developing algorithms to compute low-energy paths between molecular conformations.



AUTOMATIC CONTROL GROUP

The main objective of the automatic control line is to develop basic and applied research in advanced control, with special emphasis on modelling, control and supervision of nonlinear, complex and/or large-scale systems. The group has acquired specific expertise in the application of advanced control techniques to environmental resources management, specifically in the water and energy fields. The current topics of interest of the research line are:

01. Advanced control and optimal management of complex and large-scale systems such as water or energy networks.

02. Parameter estimation.

03. Data mining and data validation/reconstruction.

04. Real-time supervisory control, fault diagnosis and faUlt-tolerance, prognosis and system health monitoring.

05. Design of specific control strategies for fuel cells and other electrochemical energy storage systems.

Research areas:

Control, supervision and optimal management of complex and large-scale systems

The study of large-scale systems requires new methodologies for modelling, control and supervision. The main issues of large-scale systems control include model order reduction, structural analysis, decentralized hierarchical and/or distributed control using model optimal and predictive control. The main application fields of the group are water networks, electrical grids, autonomous power generation systems and robotics. We solve problems as optimal water management (both surface and pipeline systems), or optimal energy generation and distribution.

Real-time supervisory control, fault diagnosis and fault-tolerance, prognosis and system health monitoring

Real-time fault detection and isolation and fault-tolerant control are relevant topics to obtain reliable systems that have been studied by the group continuously during decades. Complementary aspects as sensor/actuator location for control and diagnosis are also addressed. On the other hand, lifetime of components has become one of the main issues of dynamic systems. This has motivated the research of new state of health and prognosis methodologies and instruments.

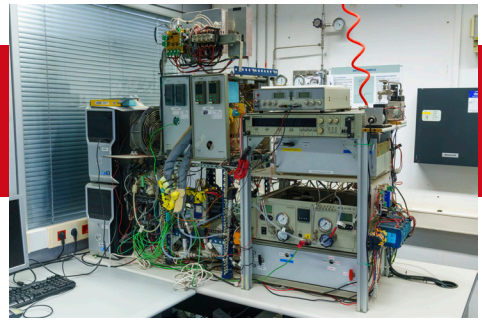
Parameter estimation

Parameter estimation is an important aspect of advanced control systems that permits to determine off-line or on-line the system features. At the same time, the research group develops non-linear observers of different complexity that permit minimizing the number of sensors and arriving at non-measurable variables.

The final objective is to integrate these estimation or observation systems with the whole control system in such a way that it can achieve a better performance, maximum efficiency and minimum degradation.

Design of control strategies for fuel cells and electrochemical energy storage systems

The group has acquired important expertise on the control of fuel cell systems, and is opening the research field to other electrochemical energy storage systems. These systems, which often work with hydrogen, are multivariable systems including multidomain phenomena.



Data mining and validation reconstruction

The group is studying data mining as a technology to support control systems whose behaviour is improved with the use of large amounts of internal or external information. The data mining system is linked with model predictive control.

2.2 RESEARCH PROJECTS

Our research projects take many forms, ranging from individual initiatives to large-scale international collaborations within consortia. We engage in diverse funding programs and strategic partnerships, driving innovation across multiple domains.

Below, we detail the most important projects developed during the period, ordered from the highest to the lowest budget.

RESEARCH PROJECTS DURING THE PERIOD 2021-2024:	
Ongoing projects: 20 EU projects 27 National projects 13 Regional and local projects 24 CSIC projects 10 UPC projects 2 Other projects	**Secured funds:** EU projects: 4.861.221,73 € National projects: 3.044.424,73 € Regional and local projects: 845.168,34 € CSIC projects: 409.150,77 € UPC projects: 62.700,00 € Other projects: 151.000 €

CLOTHILDE: Cloth manipulation learning from demonstration

CLOTHILDE established the foundations of versatile cloth manipulation by robots. Combining machine learning and computational topology, it developed a theory of cloth deformation under manipulation, leading to a framework for robots to learn garment handling from human demonstrations. Textile objects are ubiquitous in human environments, and their robotic manipulation could enable applications in elderly care, housekeeping, hospital logistics, and automated clothing businesses. While rigid object manipulation is well understood, handling cloth remains challenging due to its many degrees of freedom and unpredictable deformations.

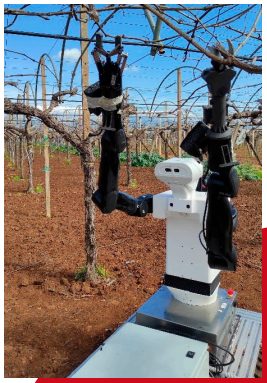
This project developed methods for robots to learn manipulation skills from human demonstrations, refining them through reinforcement learning and probabilistic planning. Key aspects included task-oriented cloth representation, failure diagnosis, and human assistance requests. Prototypes were implemented for folding clothes, placing elastic covers, and assisting disabled individuals in dressing.

- **IRI Leader:** Carme Torras
- **Period:** January 2018 - December 2023
- **RI Budget:** 2 499 149 €
- **Reference:** ERC-2016-ADG-741930
- **Funding organisation:** European Research Council

CANOPIES: A Collaborative Paradigm for Human Workers and Multi-Robot Teams in Precision Agriculture Systems

The CANOPIES project aims to create a human-robot collaboration system for dynamic, unstructured outdoor environments, specifically table-grape vineyards. It focuses on two key tasks: harvesting and pruning. This project integrates collaborative robotics in precision agriculture for permanent crops, enabling robots and farmworkers to perform tasks together. The system will address challenges such as changing light, tangled vines, and varying conditions. CANOPIES will innovate in: i) human-robot interaction for safety, ii) collaboration for adaptability, and iii) multi-robot coordination for scalability. The goal is to improve autonomous solutions for managing the complexity of permanent crops through enhanced robot-human collaboration.

- **IRI Leader:** Alberto Sanfeliu
- **Period:** January 2021 - December 2024
- **IRI Budget:** 644 794,75 €
- **Reference:** H2020-ICT-2020-2-101016906
- **Funding organisation:** European Commission
- **Consortium:**
  UNIROMA3 (IT), KTH (SE),
  UNIROMA1 (IT), IRI (ES),
  UNICLAM (IT), DTI (DE),
  PALEBLUE (NO), PAL (ES),
  AGRIMESSINA (IT), RSA Srl (IT)



SOCIAL PIA: Cooperative Social PIA model for Cybernetics Avatars

The SOCIAL-PIA project is part of Moonshot Goal 1 and aims for a society where human beings are free from physical and cognitive limitations by 2050. The project is pivotal in advancing human-cybernetic avatar co-operation, with significant implications for sectors like healthcare, education, and service industries. Its key research focus is in understanding human intention; investigating the relationship between human intention, situation awareness, and decision-making, transforming human-robot collaboration. It has as objectives to assist operators, by enhancing the management of interactive and cooperative tasks to improve efficiency; improve autonomous interaction, fostering better cooperation between CAs and end-users/bystanders, making robotic systems more intuitive; improve proactive capabilities, where the PIA paradigm will enable CAs to anticipate human actions, allowing them to be proactive or follow pre-established plans. The project will also examine cultural differences in human-robot interaction through telepresence tasks, focusing on European versus Japanese perspectives.

- **IRI Leader:** Alberto Sanfeliu
- **Period:** April 2023 - November 2025
- **IRI Budget:** 89.803.980 ¥ (571 411,70 €)
- **Reference:** JPMJMS2011-**85**
- **Funding organisation:** JST
  (Japan Science and Technology Agency)

SOFTENABLE: Towards Soft Fixture-Based Manipulation Primitives Enabling Safe Robotic Manipulation in Hazardous Healthcare and Food Handling Applications

The SOFTENABLE project proposes a new framework for manipulating delicate, deformable objects using soft fixture-enabled manipulation primitives. While robotic grasps or workpiece fixtures are commonly used for rigid objects, there is a need to adapt these methods for soft or fragile materials. SOFTENABLE will extend existing techniques with a novel soft fixture-based framework that generalizes caging grasps. The project includes the development of a soft fixture-optimized manipulator and tooling. In addition to fresh food handling, SOFTENABLE will focus on healthcare, demonstrating how soft fixtures can help healthcare workers reduce stress and risk when handling personal protective equipment (PPE).

- **IRI Leader:** Carme Torras and Júlia Borràs
- **Period:** January 2022 - September 2026
- **IRI Budget:** 554 697, 50 €
- **Reference:** HORIZON-CL4-2021-DIGITAL-EMERGING-01-101070600
- **Funding organisation:** European Commission
- **Consortium:** KTH (SE), DLR (GE), Technion (IL), IRI (ES), Ocado (UK), FCRB (ES), Hospital Clínic (ES)

TERRINET: The European robotics research infrastructure network

The TERRINet project creates a harmonized network of world-class robotics facilities, enabling researchers and industry to collaborate on groundbreaking innovations. Building on Europe's leadership in robotics, the project provides access to advanced facilities, tools, and methodologies, fostering collaboration between academia and industry. TERRINet aims to boost scientific research and technological innovation by offering resources that will remain operational beyond the project. Similarly, AI4EU unifies Europe's AI community, promoting collaboration and providing tools to drive AI advancements across various sectors, further supporting innovation in robotics and beyond.

- **IRI Leader:** Alberto Sanfeliu
- **Period:** December 2017 - November 2022
- **IRI Budget:** 384 926,25 €
- **Reference:** H2020-INFRAIA-2017-1-730994
- **Funding organisation:** European Commission
- **Consortium:** SSSA (IT), CEA (FR), CNRS (FR), KIT (GE), TUM (GE), IIT (IT), Univ Twente (NE), IRI (ES), Univ Sevilla (ES), EPFL (SW), UWE Bristol (UK), ICL (UK)

TRAIL: TRAnsparent Interpretable robots

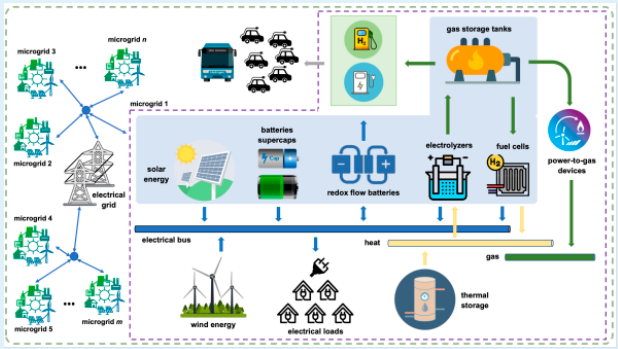
TRAIL focuses on an interdisciplinary research and training programme to enhance transparency in deep learning, AI, and robotics. The goal is to train Doctoral Candidates to become experts in designing transparent and interpretable neural systems and robots. A consortium of expert partners from AI, robotics, computer science, mathematics, social robotics, human-robot interaction, and psychology has been created. The research will address both internal decision understanding and external transparent behaviour. ESRs will analyze deep neural learning and extract efficient knowledge, while also using human-robot interaction and psychology to present the extracted knowledge in an intuitive way for cooperative human-robot interaction. A scaffolded curriculum will ensure ESRs gain deep understanding and optimal skill training, preparing them for successful careers in academia and industry. The research is supported by seven leading robotics companies, covering Europe's robot market and a broad spectrum of AI applications.

- **IRI Leader:** Guillem Alenyà
- **Period:** March 2023 - February 2027
- **IRI Budget:** 251 971,20 €
- **Reference:** HORIZON-MSCA-DN-101072488
- **Funding organisation:** European Commission
- **Consortium:** Univ Hamburg (GE), UNINA (IT), IRI (ES), Univ Bratislave (SK), UNIPD (IT), CNRS (FR), PAL (ES), ZAL (GE), Seed (PT), Honda RI (GE), United RG (GE), INSA Toulouse (FR), IT+Robotics (IT), Softbank (FR), Univ Manchester (UK)

MASHED: Efficient Management of Energy Systems including Hybrid Electrochemical Energy Storage using Digitalisation Technologies

Many European countries are shutting down aging power units to meet the EU's decarbonization goals. A decentralized system with on-site power generation and microgrids could enhance resilience against hazards. Distributed Power Generation (DPG) combined with Hybrid Energy Storage (HES) can mitigate blackout risks, especially with emerging technologies like hydrogen storage and redox flow batteries. This project develops efficient management strategies for DPG systems using a multi-layer control scheme integrating renewable energy, HES, and Combined Heat and Power (CHP). It leverages digital technologies for cloud-based monitoring, AI-driven algorithms, and addresses challenges in resilience, information flow, and cybersecurity

- **IRI Leader:** Ramon Costa
- **Period:** December 2022 - October 2025
- **IRI Budget:** 247 480 €
- **Reference:** TED2021-129927B-I00
- **Funding organisation:** AEI, Ministerio de Ciencia e Innovación



COHERENT: Collaborative hierarchical robotic explanations

COHERENT developed a framework for generating robot explanations by integrating information from different levels of the robotic architecture. This approach enabled robots to produce explainable decisions and adjust their planning in real time based on user interaction. The project proposed evaluation metrics based on trust and acceptance, defining benchmark tasks to compare different explainability approaches in human-robot interaction. The system was demonstrated in a cloth manipulation task, addressing bimanual actions, environmental constraints, and textile state perception. COHERENT integrated explainable learning techniques from perception to planning and interaction, using a unified representation, the Cohesion Graph. This framework was implemented in ROSplan to facilitate its adoption within the robotics community.

- **IRI Leader:** Júlia Borràs
- **Period:** April 2021 - March 2024
- **IRI Budget:** 199 377 €
- **Reference:** PCI2020-120718-2
- **Funding organisation:** AEI-MICIU-PRTR (ES), EPSRC (UK), MIUR (Italy)
- **Consortium:** IRI, KCL (UK), and Univ. Napoli F. II (IT)

BOTNET: New model of parcel delivery in urban superblocks using a network of autonomous electric vehicles

The BOTNET project aims to design, develop, and evaluate a parcel delivery model in urban superblocks using a network of autonomous electric vehicles. The system seeks to reduce the impact of freight transportation (pollution, noise, congestion) by using electric vehicles for distribution within superblocks. Heavy-duty vehicles will deliver goods to Urban Distribution Centers (UDCs) at the perimeter, while smaller autonomous robots will handle the final distribution. The project focuses on autonomous robot navigation and interaction with pedestrians, evaluating the scalability of this network in urban environments through a pilot in Barcelona.

- **IRI Leader:** Àngel Santamaria
- **Period:** November 2023 - May 2025
- **IRI Budget:** 145 548,29 €
- **Reference:** 23S06128-00
- **Funding organisation:** Barcelona City Hall
- **Consortium:** UPC, CIT-UPC and Vaivé Logistics

AUDEL: Autonomous package delivery in urban areas

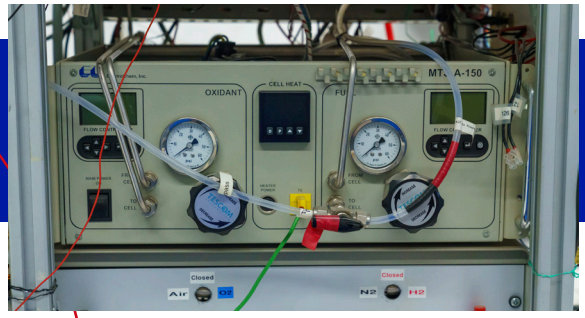
The AUDEL project focuses on developing autonomous navigation systems for delivery devices in complex urban environments. It aims to address challenges in last-mile logistics, such as traffic congestion, pedestrians, and unpredictable obstacles. Key research areas include ego-motion estimation, vulnerable road user detection, semantic understanding, and predictive control to ensure safe and efficient navigation. The project builds on previous IRI initiatives (ROCOTRANSP and LOGISMILE), focusing on autonomous navigation, human-robot collaboration, and integrating autonomous systems into urban logistics to reduce congestion, emissions, and delivery costs.

- **IRI Leader:** Àngel Santamaria
- **Period:** December 2022 - November 2024
- **IRI Budget:** 135 240 €
- **Reference:** TED2021-131759A-I00
- **Funding organisation:** AEI-MICIU-PRTR

L-BEST: Supervision and fault-tolerant control of smart infrastructures based on advanced learning and optimization

L-BEST considers research in supervision and fault-tolerant control of SIs by means of two related methodologies: advanced learning and optimization. The use of advanced learning from data is supported by the fact that SIs include sensors and smart-grid technology providing a continuous flow of operational data. First-principles models alone may not capture the complex behaviours of these SIs, so that a combination with learning from operational data is proposed. Optimization-based control is concerned with computing strategies which improve specific performance indicators, such as those related to efficiency and safety. Advanced optimization and learning are proposed for this type of problems in large-scale and complex SIs.

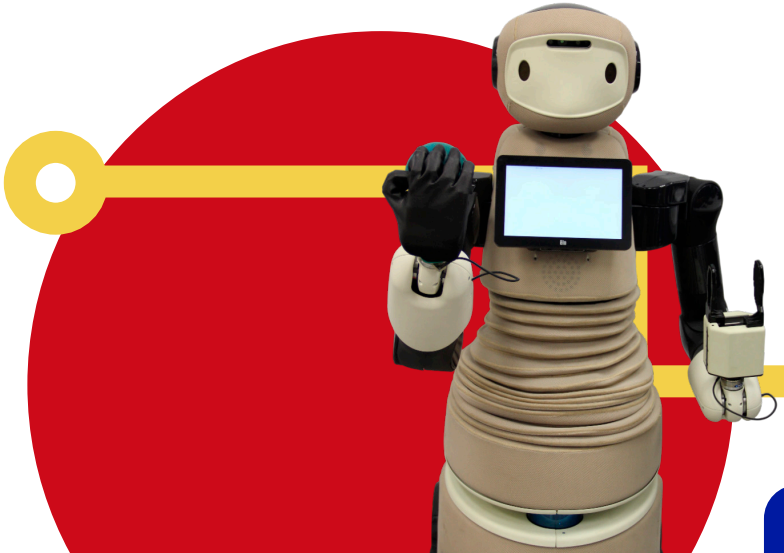
- **IRI Leader:** Gabriela Cembrano and Carlos Ocampo
- **Period:** September 2021 - August 2024
- **IRI Budget:** 112 046 €
- **Reference:** PID2020-115905RB-C21
- **Funding organisation:** AEI-MICIU



AI4EU: A European AI On Demand Platform and Ecosystem

AI4EU is the European Union's flagship AI project, aiming to develop a unified European AI ecosystem by bringing together knowledge, algorithms, tools, and resources. Involving 80 partners from 21 countries, the €20m project, launched in January 2019, fosters collaboration across AI research, innovation, and business. By facilitating collective work, AI4EU drives advancements across multiple sectors, making AI accessible to all and ensuring Europe's leadership in AI development. It empowers users by sharing expertise, knowledge, and tools through its platform.

- **IRI Leader:** Alberto Sanfeliu
- **Period:** January 2019 - December 2021
- **IRI Budget:** 111 853,13 €
- **Reference:** H2020-ICT-2018-2-825619
- **Funding organisation:** European Commission
- **Consortium:** Smile (FR), Thales (FR), Fraunhofer (GE), IMT (FR), Univ Orebro (SE), Univ Cork (IE), Univ Venezia (IT), IRI (ES), et al

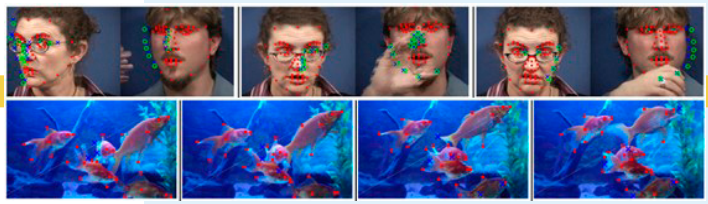


IPALM: Interactive Perception-Action-Learning for Modelling Objects

In IPALM, we developed methods for the automatic digitization of objects and their physical properties through exploratory manipulations. These methods aimed to create a large collection of object models for realistic grasping and manipulation experiments in robotics. We focused on household objects like tools, kitchenware, clothes, and food, which present challenges for robot perception and manipulation.

Our approach involved learning essential physical properties for perception and grasping from multiple modalities—vision, touch, audio, and text. We used a two-level modeling system, where category-level models provided priors to capture instance-level object attributes. The system utilized a perception-action-learning loop, where robots' sensory inputs refined object properties. Our methods allow the efficient creation of diverse object models, useful for training neural networks or enhancing simulators. Additionally, we proposed a benchmark and evaluation metrics for object manipulation, enabling comparisons across robotics platforms.

- **IRI Leader:** Francesc Moreno
- **Period:** October 2019 - December 2022
- **IRI Budget:** 111 000 €
- **Reference:** PCI2019-103386
- **Funding organisation:** AEI-MICIU (ES), EPSRC (UK), ANR (FR), AKA (FI), TACR (CZ)
- **Consortium:** ICL (UK), Univ Bordeaux (FR), IRI (ES), Aalto Univ (FI), Czech TU (CZ)



BURG: Benchmarks for Understanding Grasping

Grasping rigid objects has been studied in many settings, typically measuring success by the robot holding an object for a few seconds. However, a deeper understanding of object manipulation is needed. We propose (1) task-oriented part-based modeling of grasping and (2) BURG, a framework for setups, tools, and metrics for community building and benchmarking in object manipulation. The focus is on object parts, as they are crucial for knowing where and how to grasp, given manipulation constraints. This part-based approach extends to deformable objects, where recognizing semantic parts despite deformations is key to tractable manipulation.

BURG aims to solve issues in robotics benchmarks by providing tools for reproducible performance evaluation, enabling community collaboration across labs. The benchmark will feature repeatable scenarios with varying object types, tasks, and environments. Metrics will evaluate low-level primitives (object pose, grasp point, collision-free motion) and manipulation tasks (stacking, assembling, folding), incorporating common sense for semantic reasoning.

- **IRI Leader:** Guillem Alenyà
- **Period:** November 2019 - January 2023
- **IRI Budget:** 111 000 €
- **Reference:** PCI2019-103447
- **Funding organisation:** AEI-MICIU (ES), FWF (AT), EPSRC (UK), MIUR (IT)
- **Consortium:** TUW (AT), Univ Birmingham (UK), IIT (IT), IRI (ES)

LOGISMILE: Last mile logistics for autonomous goods delivery

The LogiSmile project aims to tackle last-mile delivery challenges in urban areas due to the rise of e-commerce. It introduces an autonomous hub vehicle (AHV) working with smaller autonomous delivery devices (ADDs), coordinated by a back-end control center. This system optimizes fleet management, reduces delivery costs, emissions, and congestion, ensuring flexible, rapid, and eco-friendly deliveries. The solution will be piloted in various cities to test its efficiency in real-world urban environments. Key partners include CARNET-UPC, Altran, TU Braunschweig, and others, focusing on integrating robots into urban logistics for sustainable operations. The project will provide valuable insights into scaling autonomous delivery solutions and enhancing urban mobility with cutting-edge robotics technologies.

- **IRI Leader:** Alberto Sanfeliu
- **Period:** January 2022 - April 2024
- **IRI Budget:** 419 669 €
- **Reference:** EIT-UM-2020-22140 / EIT-UM-2023-23374
- **Funding organisation:** European Commission
- **Consortium:** CARNET-UPC (ES), Altran (ES), City of Hamburg (GE), Tech. Univ. Braunschweig - NFF (GE), TomTom NV (NE), IRI (ES), Barcelona Metropolitan Area (ES), Dkv Debreceni Közlekedési Zrt (HU), DGT (ES), PTV, Otostolik (PO), Ay. Esplugues De Llobregat (ES)

KINODYN+: Synthesis of Optimally Agile and Graceful Robot Motions

This project develops a trajectory optimization tool capable of synthesizing agile and graceful motions in multibody systems of broad generality. The resulting method incorporates state-of-the-art optimization techniques as well as newer techniques developed by the team. These techniques extend existing methods to handle constrained robotic systems, such as parallel manipulators, robots in contact with the environment, or when virtual geometric constraints are required. They address challenges related to loop closure constraints, which introduce complex geometric structures and singularities that complicate planning. Additionally, optimizing energy-efficient trajectories will impact robotics development by increasing robot efficiency, broadening its applications, and reducing operational and construction costs by enabling lighter designs with less powerful actuators.

- **IRI Leader:** Josep Maria Porta
- **Period:** September 2021 - February 2025
- **IRI Budget:** 102 850 €
- **Reference:** PID2020-117509GB-I00
- **Funding organisation:** AEI-MICIU

EBCON: Motion estimation and control with event cameras

The EBCON project aims to develop a high-speed, high-dynamic-range localization and mapping device that integrates inertial measurements with data from event-based cameras. This approach addresses the challenges of last-mile delivery in environments lacking GPS, especially under poor lighting or rapid movement conditions. Event cameras, which capture pixel luminance changes at microsecond intervals, promise to enhance autonomous vehicles and UAV accuracy. The project explores algorithms for motion estimation and environmental mapping, using asynchronous data to recover 3D positions, velocities, and accelerations.

EBCON builds on our prior EBSLAM project, which focused on camera motion estimation and mapping at 10kHz. In EBCON, we enhance SLAM capabilities for real-time mapping and using neural networks for feature extraction and motion recovery. The project impacts high-dynamics applications, including humanoid locomotion, UAV maneuvering, and autonomous driving. Results will be validated against systems like Optitrack and demonstrated through robotic prototypes.

- **IRI Leader:** Juan Andrade and Joan Solà
- **Period:** September 2021 - August 2024
- **IRI Budget:** 90 750 €
- **Reference:** PID2020-119244GB-I00
- **Funding organisation:** AEI-MICIU

PTI+ TRANS-ENER: Fabricación del módulo BFR 50W and Hidrogenera Renovable

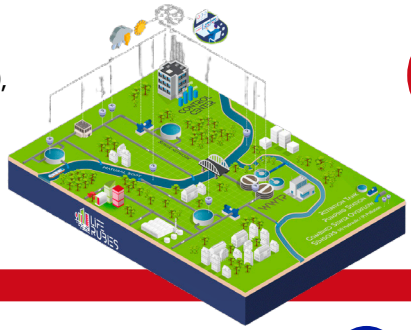
The project aims to develop an autonomous redox flow battery (vanadium-based) module optimized for 50 kW power and 250 kWh capacity. It focuses on improving electrode materials through new treatments, including heteroatoms and nanoparticles on carbon fibers. The electrochemical performance of vanadium-based electrolytes will be enhanced by new formulations and alternative electrolytes, such as iron-based eutectic liquids. The project will also optimize membranes to reduce electrical resistance and increase ion selectivity. Additionally, the fluid-mechanical design of flow frames and bipolar plates will be improved to reduce pressure loss and ensure homogeneous electrolyte distribution. A control system will be designed to ensure optimal operation and long lifespan of the battery.

- **IRI Leader:** Ramon Costa, Maria Serra
- **Period:** January 2021 - December 2023
- **IRI Budget:** 334 350 €
- **Reference:** PTI+ TRE2103000
- **Funding organisation:** CSIC
- **Consortium:** INCAR, ICB, ICMAB, ITQ, ICTP, ICMM, LIFTEC, IRI

RUBIES: Real-time pollution-based control of urban drainage and sanitation systems for protection of receiving waters

The LIFE RUBIES project aims to develop decision-making tools to limit pollution in receiving water bodies due to stormwater overflows. It will test innovative methodologies from the previous LIFE EFFIDRAIN project in real-world situations, with pilots in Lille and Madrid, representing medium and large European cities. The project will integrate these methodologies into the AQUADVANCED UD® (AQDV) platform, used for real-time monitoring, modeling, and control of wastewater systems. It will demonstrate the effectiveness of pollution-based real-time control methods in reducing stormwater overflow pollution. The project aligns with EU water policies, contributing to the Urban Waste Water Treatment Directive and Water Framework Directive, and also supports biodiversity and climate change adaptation goals.

- **IRI Leader:** Gabriela Cembrano
- **Period:** October 2021 - December 2025
- **IRI Budget:** 89 708 €
- **Reference:** LIFE20 ENV/FR/000179
- **Funding organisation:** European Commission
- **Consortium:**
  SUEZ (FR), LYRE(FR),
  Univ Lille (FR), MEL (FR),
  CETAQUA (ES),
  AQUATEC (ES),
  IRI (ES), CYII (ES)



MUYSCA: Modeling and control in open-channel irrigation Systems

Irrigation accounts for over 70% of water consumption, with water typically transported through open-channel irrigation systems (SRCAs) that lack measurement and control mechanisms. As a result, their efficiency rarely exceeds 40%. Dynamic models for water transport in SRCAs are complex and impractical for control system design, prompting researchers to propose simplified models. In the control systems field, various strategies, architectures, and configurations have been suggested to improve efficiency and reduce water waste. This research project has evaluated the most relevant modeling and control strategies and proposed new approaches to enhance SRCA efficiency.

- **IRI Leader:** Carlos Ocampo
- **Period:** April 2019 - December 2021
- **IRI Budget:** 26 000 €
- **Reference:** COOPA20246
- **Funding organisation:** CSIC

03 PUBLICATIONS

IRI's scientific production is published in the top journals of our fields of interest. This allows for an adequate dissemination of our findings to the scientific community. Moreover, our researchers also present their work in the top conferences in our fields, thus promoting the exchange of ideas with our peers at other research institutions and related companies. The evolution of IRI's scientific production in bibliometric terms has grown steadily for over a decade, and continued to do so during this period.

JOURNALS ARTICLES	CONFERENCES	BOOKS	BOOK CHAPTERS	TECHNICAL REPORTS
234 - 103 Q1s, 49 D1s	255	5	15	3

3.1 Highlighted publications

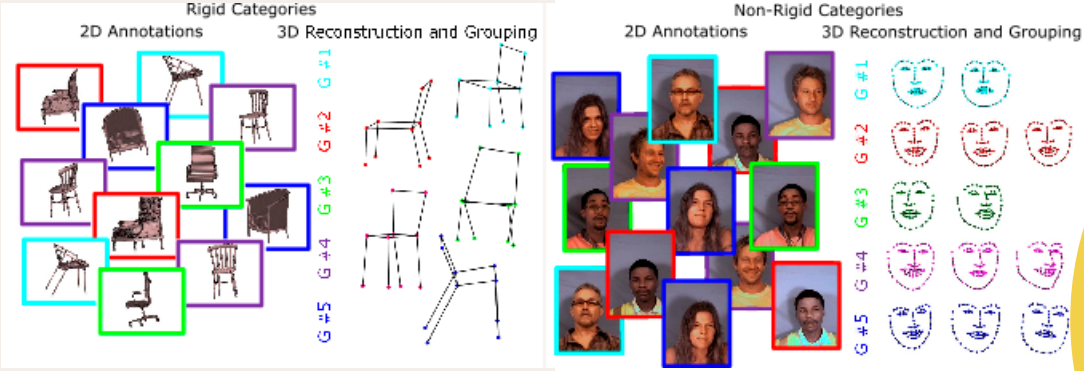
In this section, we highlight some of the most relevant publications, ordered by the last name of the first author.

A. Agha, K. Otsu, B. Morrell, D. Fan, R. Thakker, A. Santamaria-Navarro and . et al. NeBula: Team CoSTAR's robotic autonomy solution that won phase II of DARPA Subterranean Challenge. Journal of Field Robotics, 2(47): 1432–1506, 2022.

This paper presents CoSTAR's (Collaborative SubTerranean Autonomous Robots) approach in the DARPA Subterranean Challenge, where it secured top positions in Tunnel (2019) and Urban (2020) competitions. It introduces NeBula, a networked belief-aware autonomy framework designed for resilient and modular robotic exploration. NeBula enables decision-making in uncertain environments through semantic mapping, multi-modal positioning, traversability analysis, and risk-aware mission planning. The framework has been tested across various robotic platforms in extreme conditions, including Martian-analog lava tubes. Lessons learned from the competition highlight NeBula's effectiveness in autonomous subterranean and planetary exploration.

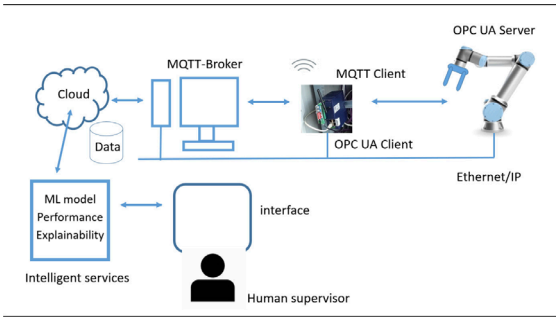
A. Agudo. Unsupervised 3D reconstruction and grouping of rigid and non-rigid categories. IEEE Transactions on Pattern Analysis and Machine Intelligence, 44(1): 519-532, 2022.

Reconstructing 3D shapes from 2D images is an important challenge in computer vision, especially for both rigid and non-rigid objects. This work presents an unsupervised method to jointly recover camera pose, 3D shape, and object grouping without prior knowledge of instance categories. By modeling deformations using unions of subspaces, the approach captures both small rigid motions and complex shape changes. The learning process, based on Augmented Lagrange Multipliers, eliminates the need for labeled training data, making it highly adaptable. Achieving state-of-the-art accuracy in diverse scenarios, this method improves object reconstruction and classification. Its impact is significant for applications in robotics and vision-based manipulation, aligning with efforts to enhance perception in autonomous systems.



C. Angulo, A. Chacón and P. Ponsa. Towards a cognitive assistant supporting human operators in the Artificial Intelligence of Things. Internet of Things, 21: 100673, 2023.

The increasing complexity of Internet of Things (IoT) systems due to device heterogeneity and real-time decision-making demands is driving the rise of Artificial Intelligence of Things (AIoT). In this context, the human operator plays a central role but faces cognitive challenges in managing intelligent systems. To address this, a joint cognitive systems approach is needed, integrating AI-driven assistants and wizards that enhance context awareness and reduce the technical workload, allowing operators to focus on tasks rather than coding. This article proposes a conceptual framework for human cyber-physical systems, offering a structured way to improve human-AI collaboration. The effectiveness of this framework is validated through two illustrative examples in collaborative tasks.

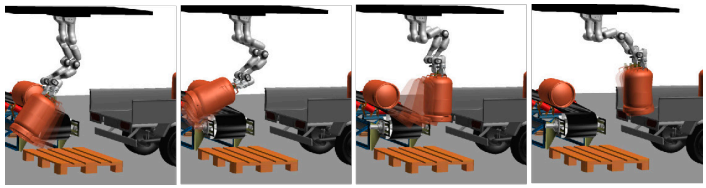


R. Bordalba, T. Schoels, L. Ros, J.M. Porta, y M. Diehl, "Direct Collocation Methods for Trajectory Optimization in Constrained Robotic Systems" IEEE Transactions on Robotics. Vol. 39. n. 1, pp. 183-202, 2023

This paper addresses the issue of kinematic drift in direct collocation methods for trajectory optimization of constrained robotic systems. Existing methods to mitigate this problem either ignore the kinematic constraints or introduce artificial forces to maintain the trajectory near the constraint manifold. In this paper we propose novel methods that achieve complete drift elimination without introducing artificial modifications of the system dynamics. Through various examples, we demonstrate the effectiveness and superiority of our approaches.

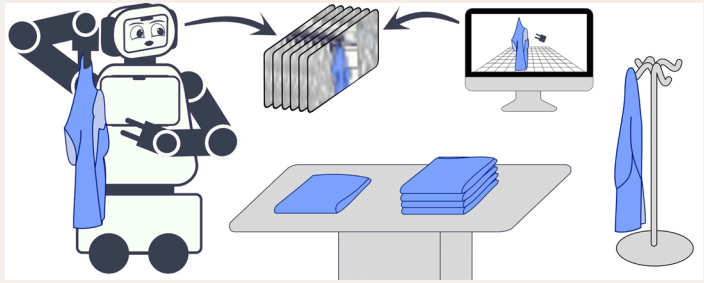
R. Bordalba, L. Ros, y J. M. Porta, "A Randomized Kinodynamic Planner for Closed-chain Robotic Systems". IEEE Transactions on Robotics. Vol. 37, n. 1, pp. 99-115, 2021.

Kinodynamic planning is one of the most challenging open problems in robotics. Given two states of a robot, the problem is to find a trajectory that connects them, while respecting the holonomic, non-holonomic, and differential constraints of the system. Among the multitude of techniques proposed to solve this problem, the RRT method by LaValle and Kuffner (2001) is one of the most successful algorithms to date. However, this algorithm cannot handle robots with closed kinematic chains, such as parallel platforms, cooperatively working manipulators, or robots that maintain contacts with the environment. This article generalizes the RRT method to be able to handle such systems.



J. Borràs. Effective grasping enables successful robot-assisted dressing. Science robotics, 7(65): eabo7229, 2022.

Effective grasping is crucial for successful robot-assisted dressing, as handling textiles presents unique challenges due to their high deformability and complex configuration space. This work highlights the importance of grasping as the first step toward reliable garment manipulation, addressing key challenges in perception, control, and interaction with deformable objects. Advances in robotic grasping improve task success rates by integrating pregrasp strategies and exploiting environmental constraints. The study contributes to the broader goal of enhancing assistive robotics for healthcare and daily life applications. Its relevance aligns with the P&M group's focus on grasping as a foundation for robotic textile manipulation, paving the way for more autonomous and adaptive robotic dressing systems.



A. Cecilia, M. Serra and R. Costa. Nonlinear adaptive observation of the liquid water saturation in polymer electrolyte membrane fuel cells. Journal of Power Sources, 492: 229641, 2021.

Efficiency, reliability, and lifetime of polymer electrolyte membrane fuel cells (PEMFCs) are greatly affected by poor water management. The absence of suitable online sensors to measure internal liquid water saturation prevents the implementation of high-performance water control algorithms. A promising alternative is the use of state observers, though their design faces challenges due to strong nonlinearities, model uncertainties, unknown parameters, and sensor noise. This study proposes a time-varying adaptive observer to estimate the liquid water state in the cathode catalyst layer, combined with a low-power peaking-free observer with dynamic dead-zone filtering. The algorithm ensures accurate estimation of liquid water saturation and transport parameters despite sensor noise and model inaccuracies. The approach is validated through numerical simulations and real experimental testing.

W.O. Chamorro, J. Solà and J. Andrade-Cetto. Event-IMU fusion strategies for faster-than-IMU estimation throughput, 4th CVPR Int. Workshop on Event Vision, 2023, Vancouver, pp. 3975-3982. Best paper award finalist.

This study introduces novel fusion strategies for integrating event data and IMU readings to achieve ultra-fast camera pose estimation. Traditional predict-with-IMU-correct-with-vision methods are suboptimal, as events are generated much faster than IMU data. Two Kalman filter-based fusion schemes are proposed: one treats IMU data as instantaneous acceleration and angular rate, while the other considers them as averaged values. Tested in a PTAM system and compared against event-only and frame-based methods, these strategies achieve 100× faster throughput than state-of-the-art approaches, offering superior real-time tracking in indoor environments..

A. Clemente, M. Montiel, F. Barreras, A. Lozano and R. Costa. Experimental validation of a vanadium redox flow battery model for state of charge and state of health estimation. Electrochimica Acta, 449: 142117, 2023.

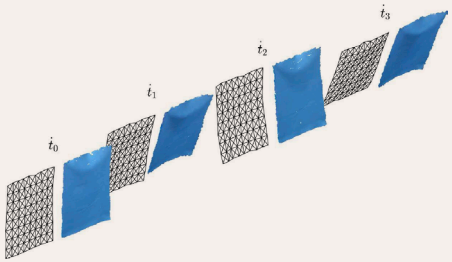
This study introduces a vanadium redox flow battery model that incorporates key variables affecting system performance. The model is structured into four sub-models: electrochemical, thermal, hydraulic, and voltage. An analytical analysis is performed to reduce system order based on conservation laws. Following this, model parameters are calibrated using real experimental data.Validation is conducted by comparing measured voltage with model-estimated values. Calibration is achieved through a particle swarm optimization algorithm. Results from both short- and long-term operation are presented to assess the model's accuracy in estimating the state of charge and state of health, confirming its suitability for these applications.

A. Clemente, M. Montiel, F. Barreras, A. Lozano, B. Escachx and R. Costa. Online estimation of the state of charge and state of health of a vanadium redox flow battery. Journal of Power Sources, 598: 234181, 2024.

This study presents an online algorithm for the simultaneous estimation of the state of charge and state of health of a vanadium redox flow battery. Starting from a general electrochemical model, order reductions are applied based on conservation laws. These reduced-order models serve as the foundation for an observer designed using the battery's terminal voltage. The algorithm is first analyzed through numerical simulations to assess its performance and stability. Then, an experimental validation is conducted using real data from a vanadium redox flow battery stack, consisting of current and voltage measurements. The results demonstrate the effectiveness of the proposed observer in accurately estimating the battery's internal states, contributing to improved monitoring and management of vanadium redox flow battery systems.

F. Coltraro, J. Amorós, M. Alberich-Carramiñana and C. Torras. An inextensible model for the robotic manipulation of textiles. Applied Mathematical Modelling, 101: 832-858, 2022.

Modeling textile dynamics accurately is essential for robotic manipulation, especially in human-centered environments. This work introduces an inextensible strain model that ensures consistency across meshes, preventing locking issues and improving simulation precision. By incorporating aerodynamic effects, the model achieves high accuracy, with errors under 1 cm, even with coarse meshes. Its ability to replicate real-world textile behavior makes it a valuable tool for advancing robotic grasping and manipulation. This research is particularly relevant to the P&M group's focus on robotic grasping as a first step toward effective textile handling. The model's precision and efficiency enhance the development of autonomous robots capable of interacting safely and reliably with deformable objects.



M. Dalmasso, A. Garrell Zulueta, J.E. Domínguez, P. Jiménez and A. Sanfeliu. Human-robot collaborative multi-agent path planning using Monte Carlo tree search and social reward sources, IEEE Int. Conf. Robotics and Automation, 2021, Xian, China, pp. 10133-10138.

Human-robot collaboration in object search tasks requires shared plans achieved through communication and negotiation. This work proposes an approach where the robot generates a multi-agent plan, which is then reviewed by the human, who may modify it, forcing the robot to adapt iteratively. It is based on a decentralized variant of Monte Carlo Tree Search (MCTS), optimizing actions through a probability distribution in a joint action space. The method supports intermittent communication and real-time replanning. Validation includes real-world search experiments in urban environments and an acceptability study. This research is crucial for improving human-robot interaction and autonomy in dynamic settings.

I. del Pino, A. Santamaria-Navarro, A. Garrell Zulueta, F. Torres and J. Andrade-Cetto. Probabilistic graph-based real-time ground segmentation for urban robotics. IEEE Tran. Intelligent Vehicles, 9(5): 4989-5002, 2024.

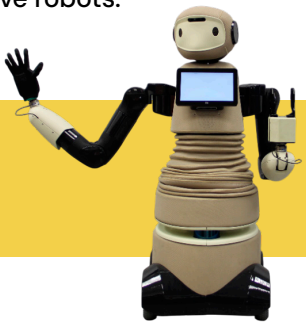
Terrain analysis is crucial for autonomous robot navigation. This study presents GATA, a probabilistic real-time graph-based method for point cloud segmentation and traversability analysis. GATA iteratively refines a ground plane model, distinguishing traversable from non-traversable regions captured by LiDAR. It outperforms state-of-the-art methods in precision and speed. Additionally, GATA integrates a shallow neural network to differentiate surfaces with varying traversability, such as vegetation or unpaved roads, enhancing adaptability. Importantly, it maintains real-time efficiency without GPUs. The method is validated using SemanticKITTI and real-world urban delivery robot experiments. The code is publicly available.

A. Dhamanaskar, M. Dimiccoli, E. Corona, A. Pumarola and F. Moreno-Noguer. Enhancing egocentric 3D pose estimation with third person views. Pattern Recognition, 138(109358), 2023.

This work improves 3D body pose estimation from egocentric videos using a novel joint embedding space that links first- and third-person views. To achieve this, it introduces First2Third-Pose, a dataset of nearly 2,000 synchronized videos capturing human activities from both perspectives. A semi-Siamese architecture, trained in a self-supervised manner, integrates spatial and motion-domain features without requiring domain adaptation or camera parameters. Extensive evaluations show that this approach outperforms three state-of-the-art supervised methods on unconstrained datasets. By enhancing egocentric pose estimation, this research advances applications in AR, VR, and human-robot interaction. The dataset and pre-trained model are publicly available.

J.E. Dominguez-Vidal and A. Sanfeliu. Anticipation and proactivity. Unraveling both concepts in human-robot interaction through a handover example. IEEE Int. Sym. Robot and Human Interactive Communication, Pasadena, 2024.

Collaborative tasks require robots to understand human intentions to reduce uncertainty. While anticipatory and proactive behaviors are key to improving Human-Robot Interaction (HRI), they are often conflated in the literature. This study clarifies their distinction and examines their effects in a handover scenario. A user study with 24 participants and 72 experiments found that humans can differentiate these behaviors, with proactive actions significantly increasing the robot's perceived anthropomorphism. Both anticipation and proactivity enhance key HRI aspects such as fluency, comfort, and performance, though no clear preference for one over the other was identified. These findings contribute to designing more intuitive and effective collaborative robots.

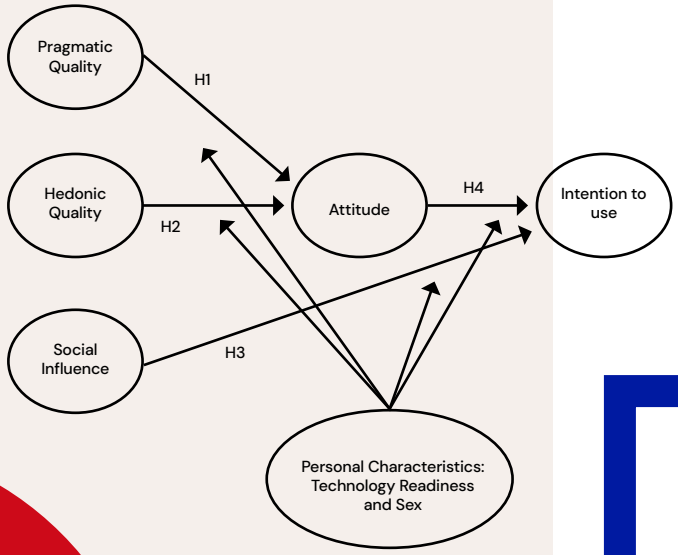


S. Forgas, R. Huertas, A. Andriella and G. Alenyà. Social robot-delivered customer-facing services: an assessment of the experience. The Service Industries Journal, 43(3): 154-184, 2023.

Integrating social intelligence in robots enhances their conversational abilities, making them ideal for cognitive service delivery. This study examines how these capabilities affect customer experience and service continuation intent. A simulated service scenario analyzed the role of technology readiness and gender as moderating factors. Results show that hedonic quality strongly influences attitude, which in turn affects intention to use and social influence. Among technology readiness traits, optimism and innovativeness are key moderators. Findings suggest that adapting to social robot technology requires engagement from both providers and users, paving the way for future adoption in service industries.

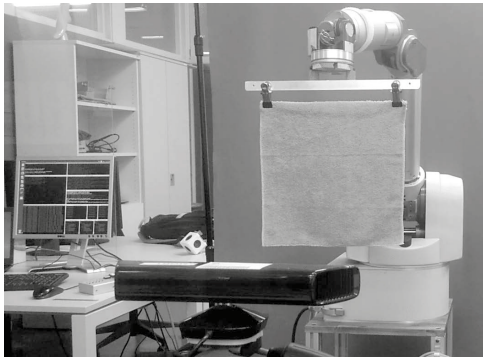
J. Laplaza, F. Moreno, and A. Sanfeliu, Enhancing robotic collaborative tasks through contextual human motion prediction and intention inference, Int. J. Social Robotics, 2024, To appear.

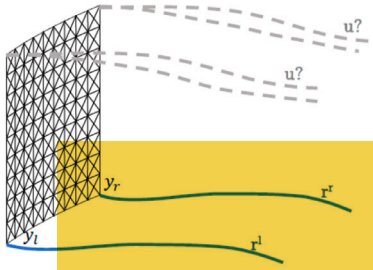
Predicting human motion is essential for robotics and computer vision, yet existing datasets fail to account for human behavior in the presence of robots. This work introduces a deep learning architecture that predicts both 3D human motion and human intention in collaborative tasks. Using a multi-head attention mechanism, the model integrates human motion and task context to enhance prediction accuracy. It has been validated in two scenarios: object handover and collaborative grape harvesting. A user study assessed human perception of the robot's sociability, naturalness, and comfort, showing improved interactions when predictions were used. The model's adaptability allows for diverse real-world applications, advancing.



A. Luque, D. Parent, A. Colomé, C. Ocampo-Martínez and C. Torras. Model predictive control for dynamic cloth manipulation: Parameter learning and experimental validation. IEEE Transactions on Control Systems Technology, 32(4): 1254-1270, 2024.

Robotic cloth manipulation is highly challenging due to textiles' ever-changing shapes. This study presents a Model Predictive Control (MPC) approach to indirectly control textile configurations by applying forces to specific points. MPC predicts future behavior while ensuring physical and operational constraints are met. A linear cloth model enables real-time optimization, with reinforcement learning (RL) used to refine model parameters and improve control accuracy. The method was validated on a real robot, achieving precise trajectory tracking even under adverse conditions. This work is especially relevant for the IRI, as it represents a collaboration between the Perception & Manipulation (P&M) and Control groups, combining expertise in robotic perception, modeling, and control for advanced textile manipulation.



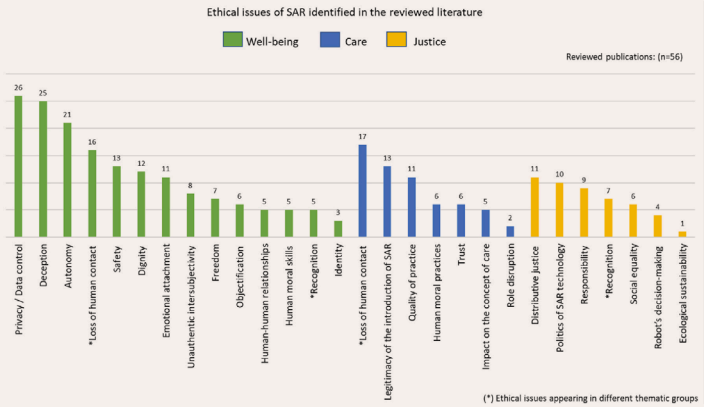


A. Olivares-Alarcos, S. Foix, S. Borgo and G. Alenyà. OCRA – An ontology for collaborative robotics and adaptation. Computers in Industry, 132: 103627, 2022.

Future industrial robots must collaborate safely with humans in unstructured environments, adapting to uncertainty and safety constraints. This work presents OCRA, an ontology that enables robots to reason about collaboration and plan adaptation, ensuring reliable teamwork. By structuring knowledge representation, OCRA enhances reusability across different tasks and scenarios, allowing robots to formalize and adjust their plans dynamically. The ontology is validated through competency questions and extreme cases, demonstrating its robustness. This advancement is crucial for developing more autonomous, flexible, and trustworthy collaborative robots, bridging the gap between industrial automation and human-robot interaction, a key challenge in the evolution of smart manufacturing.

J. Pareto, B. Román and C. Torras. The ethical issues of social assistive robotics: A critical literature review. Technology in Society, 67: 101726, 2021.

Social assistive robotics raises critical ethical concerns as it becomes more integrated into care practices. This work provides a structured review of the fragmented ethical debate, categorizing key issues into well-being, care, and justice. By analyzing existing discussions, it identifies gaps and future research directions to enhance ethical oversight in robotic assistance. Addressing these concerns is essential to ensure trust, safety, and fairness in human-robot interactions, particularly in healthcare and elder care. The study contributes to shaping responsible robotics policies and frameworks. Its relevance extends to the broader discourse on AI ethics, emphasizing the need for normative guidelines that balance technological progress with social responsibility.



J Martí-Saumell, H Duarte, P Grosch, J Andrade-Cetto, A. Santamaria-Navarro, and J. Solà. Borinot: an open thrust-torque-controlled robot for research on agile aerial-contact motion arXiv preprint arXiv:2307.14686.

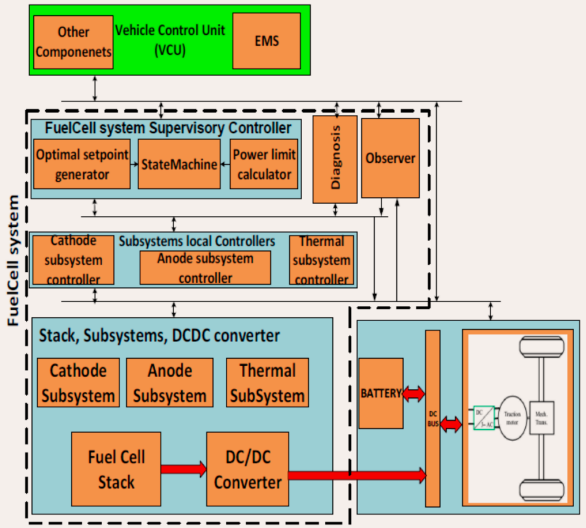
Borinot is an open-source aerial robotic platform designed for research on hybrid agile locomotion and manipulation using both flight and contact interactions. It features a powerful hexarotor that can be equipped with torque-actuated limbs, enabling whole-body dynamic control for agile maneuvers. These limbs can function as legs for locomotion, arms for manipulation, or tails to influence flight dynamics, mimicking animal movements. This flexibility makes Borinot ideal for studying hybrid aerial-contact motion. A 2DoF limb and torque-level model predictive control (MPC) were implemented to showcase its agility, positioning Borinot as a versatile platform for advanced robotics research.

C. Mastalli, W. Merkt, J. Martí, H. Ferrolho, J. Solà, N. Mansard and S. Vijayakumar. A feasibility-driven approach to control-limited DDP. Autonomous Robots, 46(8): 985–1005, 2022.

This work improves Differential Dynamic Programming (DDP), a trajectory optimization method, by addressing its numerical instability, control constraints, and limited initialization options. The proposed Box-FDDP introduces a feasibility-driven approach, ensuring dynamic feasibility and control limits during optimization. It effectively emulates multiple shooting methods while maintaining DDP's efficiency. Results show better numerical convergence than Box-DDP and performance competitive with state-of-the-art solvers. Box-FDDP also monotonically reduces feasibility errors, making it ideal for complex motions in quadrupeds and humanoids, and well-suited for model predictive control in legged robots.

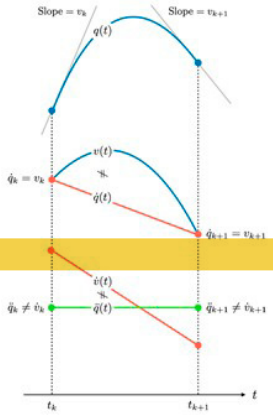
A. Molavi, M. Serra and A.P. Husar. Improved supervisory controller design for a fuel cell hybrid electric vehicle. IEEE Transactions on Vehicular Technology, 73(4): 4918-4933, 2024.

A supervisory controller is developed for a fuel cell system in fuel cell-based hybrid electric vehicles. It aims to safely manage powertrain component interactions, maximize efficiency, and minimize fuel cell degradation. The controller features a state machine to coordinate subsystems (anode, cathode, thermal, DC/DC), an optimal setpoint generator using a comprehensive stack model, and a power limit calculator for vehicle energy management. Validated with real data and simulations on the CADC cycle, it demonstrates proper operation.



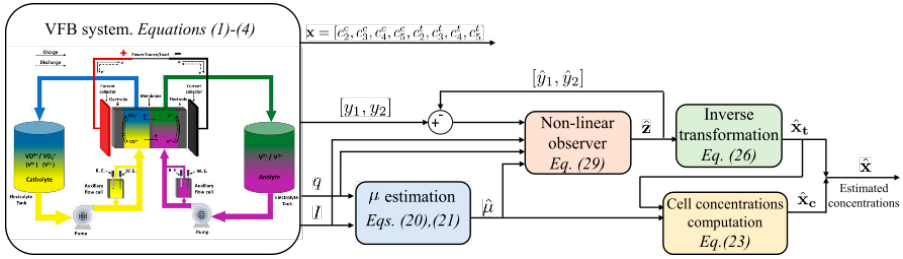
S. Moreno, L. Ros and E. Celaya. Collocation methods for second order systems, XVIII Robotics: Science and Systems Conference, 2022, New York, pp. 1-11.

Collocation methods for robot optimal control often incorrectly treat higher-order dynamics as first-order ODEs. This standard conversion for discretization leads to inconsistencies because configuration variables and their derivatives are approximated with same-degree polynomials, violating their dependencies. The actual dynamics aren't satisfied, even at collocation points. This paper presents improved trapezoidal and Hermite-Simpson methods that avoid these flaws. These new methods drastically reduce dynamics transcription error (often by an order of magnitude) without significantly increasing computation. This leads to more accurate robot trajectory optimization. Standard collocation practices for robotics need reevaluation.



T.P. Puleston, A. Cecilia, R. Costa and M. Serra. Nonlinear observer for online concentration estimation in vanadium flow batteries based on half-cell voltage measurements. Computers and Chemical Engineering, 185: 108664, 2024.

This paper presents a nonlinear observer for estimating active species concentrations in vanadium flow batteries, using only current, flow rate, and two half-cell voltage measurements. Unlike previous methods, this observer handles low flow rates—causing concentration differences between tanks and cells—and accounts for crossover and oxidation side reactions, leading to electrolyte imbalances. Stability and convergence are formally proven via Lyapunov analysis and validated through simulations. Additionally, the observer enables independent electrolyte flow rate control based on state of charge, optimizing battery performance and supporting SoC and SoH monitoring.

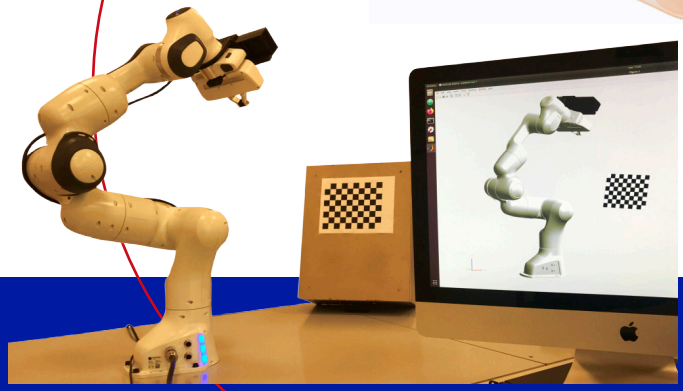


S. Sarabandi, J.M. Porta and F. Thomas. Hand-eye calibration made easy through a closed-form two-stage method. IEEE Robotics and Automation Letters, 7(2): 3679-3686, 2022.

An analysis of the existing hand-eye calibration methods reveals that most of them are far from trivial, and, what is worse, their intrinsic complexity makes it difficult to elucidate under which circumstances they fail to provide an accurate solution. After reviewing the most representative methods, we analyze the situations in which they fail, and we introduce a simpler closed-form alternative that accurately solves the problem in all the identified critical circumstances. Its performance is evaluated using simulated and real experimental data.

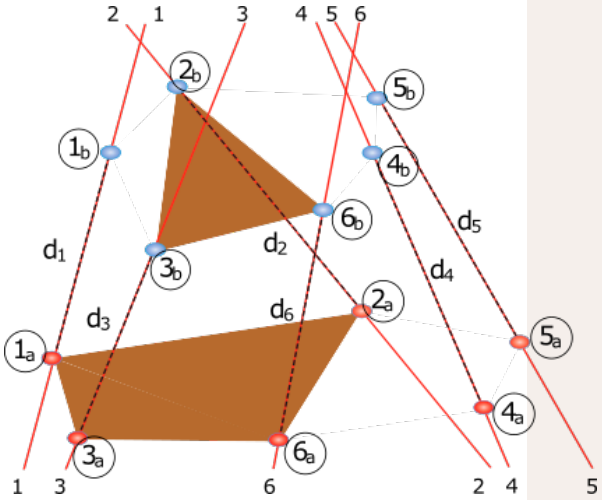
F. Thomas and J.M. Porta. The inverse kinematics of lobster arms. Mechanism and Machine Theory, 196: 105630, 2024.

In this paper, we derive closure polynomials of 6R robots in terms of distances. The use of a distance-based formulation provides a fundamental advantage since it leads to closure conditions without requiring neither variable eliminations nor variable substitutions. We restrict our attention, though, to robots with coplanar consecutive joint axes. This family of robots include broadly used offset-wrist arms. For instance, in this paper, we obtain closure polynomials for robots such as the FANUC CRX-10iA/L, the UR10e, and the KUKA LBR iiwa R800 robot in generic form (i.e., as a function of their end-effector locations).



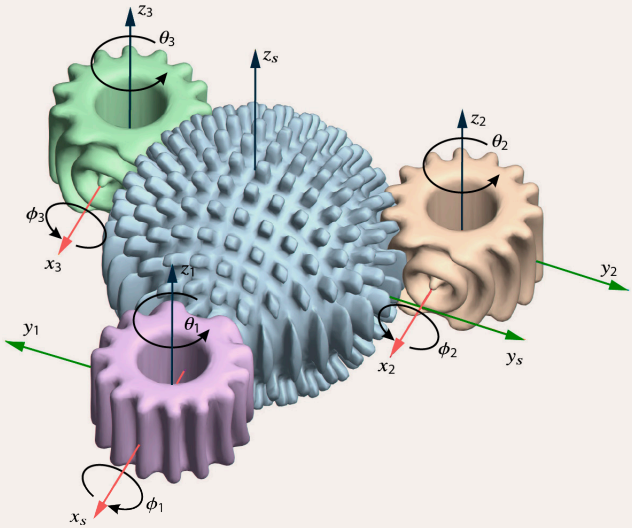
F. Thomas. New bracket polynomials associated with the general Gough-Stewart parallel robot singularities, IEEE International Conference on Robotics and Automation, 2023, London (UK), pp. 9728-9734

In this paper, we derive simple conditions characterizing the singularities of parallel robots. The identification and avoidance of singularities are issues of practical importance since, at singularities, the controllability or the stability of the robots might be compromised. This paper was a finalist for the Best Paper Award of ICRA 2023.



F. Thomas. Kinematics of a gear-based spherical mechanism, 18th International Symposium on Advances in Robot Kinematics, 2022, Bilbao, Vol 24 of Springer Proceedings in Advanced Robotics, pp. 323-331

In this paper, we propose a variation on the ABENICS mechanism which requires only three actuators instead of four, thus simplifying its control and its potential cost. The kinematics of this new mechanism is studied in detail, including its forward and inverse kinematics, as well as its singularities. This paper was awarded with the Best Paper Gold Award at the International Conference on Advances in Robot Kinematics 2022.



04 EDUCATION

We are committed to fostering excellence in advanced scientific education, actively engaging in the mentorship and training of undergraduate, master's, and PhD students. Through personalized guidance and hands-on research experience, we aim to cultivate the next generation of scientific leaders and innovators.

STUDENTS SUPERVISION IN 2021-2024

51 PhD Theses

49 Master Theses

28 Undergraduate projects

4.1 Highlighted PhD Theses

Next we highlight some of the most relevant PhD Theses defended in the period, ordered by the last name of the Phd student.

Antonio Andriella (2022): Personalising robot assistance for cognitive training therapy.
Supervisors: Guillem Alenyà and Carme Torras.

This thesis focuses on developing a fully autonomous robot for delivering cognitive training, emphasizing personalization through adaptable and adaptive robots. Adaptable robots allow therapists to customize high-level behaviors, while adaptive robots tailor interventions to individual needs over time. The work takes a therapist-oriented approach, incorporating healthcare professionals' expertise into the design of the robot's functionalities. The thesis explores the impact of human-like robot characteristics, such as personality and communication style, on user engagement and performance. It also investigates AI techniques for learning socially assistive behaviors suited to users' abilities. The thesis introduces CARESSER, a novel framework enabling therapists to customize assistive behaviors and allowing the robot to autonomously learn patient-specific policies, making it both adaptable and adaptive in real-time.

Awards:

- **2022 AIHUB.CSIC** prize for the best AI PhD Thesis by the AI Hub of CSIC
- **Georges-Giralt PhD** Award to the best PhD Thesis on Robotics by euRobotics (2023)
- **2024 edition** of the Premis Extraordinaris de Doctorat of the UPC.

Ricard Bordalba (2021): Kinodynamic Planning and Control of Closed-chain Robotic System.
Supervisors: Lluís Ros and Josep M. Porta.

This thesis presents a novel methodology for kinodynamic planning and control of robots with closed kinematic chains. Kinodynamic planning accounts for both the kinematic and dynamic constraints of the robot, ensuring more realistic and efficient motions. The primary challenge lies in the non-globally parameterizable state space of closed-chain systems. The proposed methodology consists of three steps. 1.Trajectory Generation: A sampling-based planner constructs local charts of the state space to avoid collisions and satisfy kinodynamic constraints, including loop-closure constraints and dynamic limits; 2.Trajectory Optimization: Two new collocation methods are introduced to optimize the trajectory while ensuring constraint satisfaction; 3.Trajectory Control: Two control methods are developed, one with global stability but limited to singularity-free trajectories, and the other with local stability but allowing robust singularity traversal. This approach extends the applicability of motion planning to a wider range of robotic systems with closed kinematic chains.

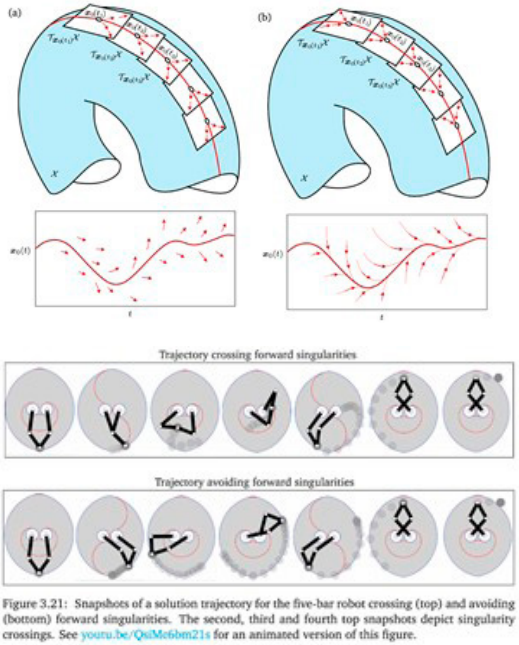


Figure 3.21: Snapshots of a solution trajectory for the five-bar robot crossing (top) and avoiding (bottom) forward singularities. The second, third and fourth top snapshots depict singularity crossings. See youru.be/QsiMe6bm21s for an animated version of this figure.

Andreu Cecília (2022): Advances in nonlinear observer design for state and parameter estimation in energy systems.
Supervisors: Maria Serra and Ramon Costa

This thesis presents advancements in nonlinear observer design, particularly focusing on high-gain observers. It addresses the integration of filters to reduce noise, an area largely overlooked in literature, and the adaptive redesign of observers to handle parametric uncertainty. Classical method limitations are discussed, with solutions formalized through Lyapunov stability analysis and validated by simulations. The second part applies adaptive nonlinear observers to estimate liquid water in hydrogen fuel cells and detect false data injection attacks in DC microgrids. The thesis highlights the implementation of continuous-time nonlinear observers in energy systems, which face nonlinearities, noise, and uncertainty. Motivated by critical energy challenges, it emphasizes the need for efficient estimation algorithms to monitor unmeasured internal variables in energy systems, given the limitations of sensor integration and the evolving demands of renewable energy, distributed generation, and autonomy.

Alejandro Clemente (2023): Modeling and control of a vanadium redox flow battery.
Supervisor: Ramon Costa

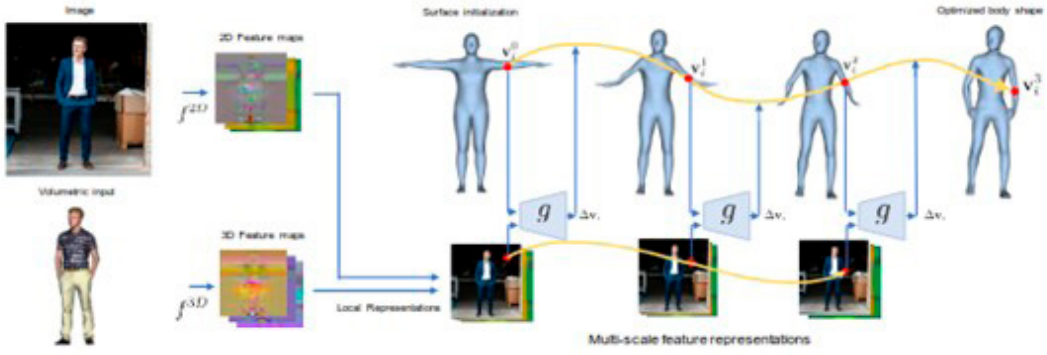
This thesis focuses on the modeling and control aspects of vanadium redox flow batteries, fields that are still being studied by the scientific community, in need of finding adequate control laws, as well as state and parameter estimators. The first part it focuses on presenting the operation and characteristics of vanadium redox flow batteries, as well as developing a state of the art in terms of modeling and control. The second part presents the mathematical development of a model that takes into account the most important aspects and variables of vanadium batteries, under different chemical and physical scenarios. The developed generic model is presented as a tool for anyone interested in understanding the most important dynamics of these electrochemical devices, providing a free-to-use interface in the Matlab environment. The following chapters present the development of the state and parameter estimators, considering the different models. The main objective is to present new and different control techniques that allow estimating the state of charge and the state of health of the system, without considering some hypotheses that are commonly used by the scientific community. Finally, the experimental platform that has been designed to validate the different studies carried out and the results obtained from this experimental prototype is shown.

Franco Coltraro (2023): Robotic manipulation of cloth: mechanical modeling and perception.
Supervisors: Maria Alberich and Jaume Amorós

The aim of this thesis is to set a mathematical framework useful for cloth representation. It focusES on the development of algorithms for the effective calculation of Algebraic Topology invariants, and on their application for the representation of topological characteristics of clothing that are relevant to its robotic manipulation. We study various mathematical problems arising from the robotic manipulation of cloth. We prove that a generic simple, closed, piecewise regular curve in space can be the boundary of only finitely many developable surfaces with nonvanishing mean curvature. Inspired by this result we introduce the dGLI cloth coordinates, a low-dimensional representation of the state of a piece of cloth based on a directional derivative of the Gauss Linking Integral. These coordinates --computed from the position of the cloth's boundary-- allow to distinguish key qualitative changes in folding sequences.

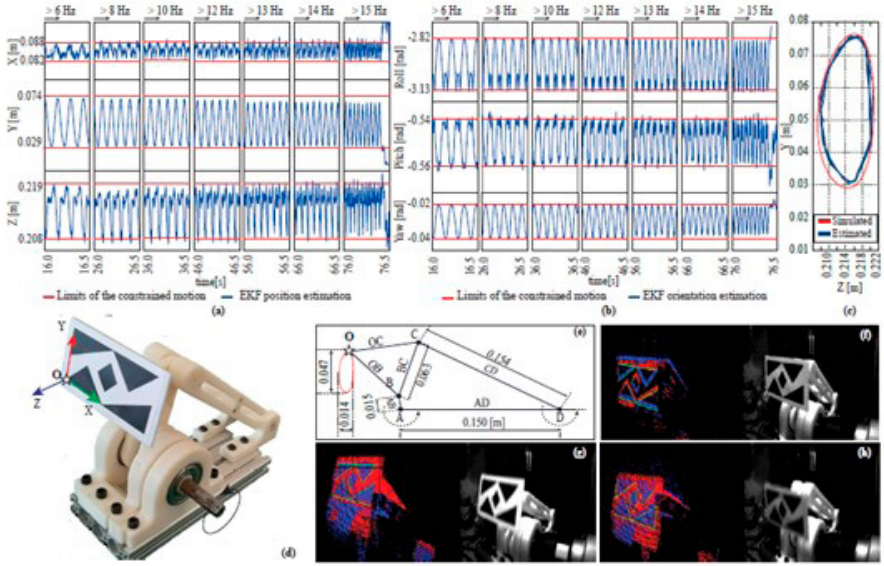
Enric Corona (2023): Modeling and Reconstruction of 3D Humans.
Supervisors: Francesc Moreno and Guillem Alenyà

This thesis investigates new approaches for prediction and understanding of 3D human pose, shape, and motion, by leveraging novel geometric cues. We study methods for human perception while taking context into account. The environment conditions human actions and motion and our actions are also designed to have an effect on the scene. In particular, we use deep neural networks to build new algorithms that exploit geometric and semantic priors, currently not integrated within most state-of-the-art models. Semantic information can be explicitly given to the model during training, but ground truth human-object interaction data is scarce and, ideally, it should be learnt without any supervision. Moreover, this will allow to understand what contextual cues are learnt by the model to achieve a given task. For this, we study the use of unsupervised training methods such as Variational Autoencoders or Generative Adversarial Networks. Geometric priors, in contrast, can be integrated via loss functions or other architectural designs that exploit how the 3D world is structured. Vision-based analysis of humans and their actions is an active research area, with potential applications in robotics and VR/AR. This thesis was directed by Francesc Moreno Noguer and Guillem Alenyà Ribas.



William Oswaldo (2023): Event-based SLAM.
Supervisors: Juan Andrade and Joan Solà

Event-based cameras are bio-inspired sensors with high dynamic range and low latency, generating asynchronous streams of events based on pixel-level brightness changes. These cameras capture fast motion without image blurring or exposure issues, making them ideal for high-dynamic and challenging lighting applications. However, their unique sensing principle requires new algorithms to process the absence of image intensity. This thesis explores monocular event-based solutions for the Simultaneous Localization and Mapping (SLAM) problem in human-made environments. Leveraging the event camera's edge response, a high-speed camera pose tracking approach is proposed, using line features and fast data-association for accurate 6 degrees-of-freedom motion estimation. Both event-per-event and window-of-events tracking are evaluated for real-time feasibility. Additionally, sensor fusion techniques integrate events with inertial data, improving estimation while balancing the motion dynamics and data rates. A mapping method is also introduced, optimizing straight-line features for more representative maps in structured environments. This thesis demonstrates event-based tracking and mapping with line features, outperforming conventional frame-based SLAM methods in real-time, dynamic, and challenging conditions. Validation through extensive experiments confirms the approach's accuracy and real-time performance.



Júlia Pareto (2024): Ètica de les tecnologies: Coordenades teòrico-pràctiques per a la robòtica social.
Supervisors: Carme Torras and Begoña Román

This thesis responds to the need to address the deployment of social robotics from the ethics perspective, especially regarding its assistive branch. It obeys two primary purposes. The first goal is establishing a conceptual framework for a proper approach to social robotics through a double task. On the one hand, the disciplinary foundations for the ethical approach to this technology are grounded through clarifying three key questions: why does technology require ethics, what kind of ethics is it, and what is the statute of technology ethics? On the other hand, some specific ethical coordinates for social assistive robotics are defined; that is, coordinates to identify and analyse the normatively relevant issues for its deployment, in line with the statute of applied ethics appropriate to the ethics of technology. The second goal is to reexamine some central ethical issues of social assistive robotics. Social assistive robotics is examined from one of the previously defined ethical coordinates, namely freedom, thereby expanding the scope of normative consideration beyond the sphere of dyadic human-robot interaction.

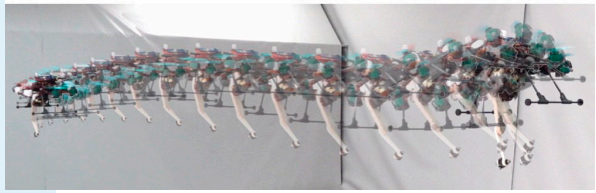
Additionally, given the need for innovative teaching programs on ethics in university engineering degrees, the thesis proposes a teaching plan for a technology ethics subject of 6ECTS credits.

Albert Pumarola (2021): Bridging the gap between reconstruction and synthesis.
Supervisors: Francesc Moreno and Alberto Sanfeliu

Albert received the ECCV Best paper Award in 2018. He is now a research scientist at Meta working on generative AI for media generation. This thesis focuses on advancing 3D reconstruction and image synthesis, two key areas in computer vision. Initially, these tasks were simpler, but with deep learning, they have evolved to handle more complex challenges. The work developed here spans a wide range of problems, combining computer vision, graphics, and machine learning. The research advocates for integrating prior 3D geometric knowledge into deep learning models, rather than relying on the technology alone. The proposed methods improve 3D scene and person reconstruction, camera position estimation, and photo-realistic rendering. Additionally, image and video synthesis for clothed people is addressed, eventually merging reconstruction and synthesis under a novel framework. The results show improved 3D shapes and images with less training data and supervision. This thesis provides tools at various stages of the deep learning pipeline to enhance performance in 3D reconstruction and synthesis tasks.

Josep Martí (2024): Agile aerial manipulation: an approach based on full-body dynamics and model predictive control.
Supervisors: Àngel Santamaria and Joan Solà

This thesis focuses on enhancing the agility of aerial manipulators, which typically use their limbs for manipulation rather than movement. It explores various limb roles, such as using limbs for aerial locomotion, manipulation, or hybrid aerial-contact movement. The research includes key contributions to generating and controlling agile motions and the design of the Borinot platform, a specialized aerial manipulator. Optimal control and model predictive control (MPC) techniques are applied to generate agile movements while considering whole-body dynamics. Two differential dynamic programming (DDP)-based methods address control bounds for feasible trajectories. The Borinot platform features a hexarotor and torque-actuated limbs for dynamic control. The thesis also addresses challenges in predictive capabilities by updating terminal cost functions during iterations. Experimental results demonstrate the effectiveness of these approaches in achieving agile motions.



Alberto San Miguel (2023): Safety and adaptation in physical interaction control for robotic applications.
Supervisors: Guillem Alenyà and Vicenç Puig.

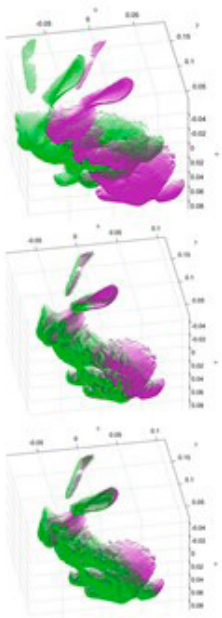
The thesis focuses on tackle the supervision and control problem of those robots which have to work on complex and highly unpredictable anthropic domains, assuring human safety and task fulfillment. It proposes the use of a model-based approach using Linear Parameter Varying (LPV) paradigm to formulate solutions and systems in combination with the formulation of conditions in terms of Linear Matrix Inequalities (LMI). The LPV representation provides linear-like descriptions through a set of varying parameters. In such way, a depiction of its complete range of operation can be defined by only considering the limits of these parameters. This Thesis presents methods addressing different problems in robotic manipulators, all of them using the LPV-LMI framework. Obtained results show that the LPV-LMI framework represents a promising systematic approach to ensure a safe behaviour on different control solutions with minimal limitations to adaptation strategies in physical interaction tasks.

Soheil Sarabandi (2021): Solving the Nearest Rotation Matrix Problem in Three and Four Dimensions with Applications in Robotics.
Supervisors: Federico Thomas.

Awards:

- This thesis received the UPC's Doctoral Special Award in the mechanics modality.

This thesis addresses the problem of finding the closest rotation matrix in 3D and 4D. We focus our attention in obtaining closed-form solutions, in particular those that only require the four basic arithmetic operations because they can easily be implemented on microcomputers with limited computational resources. Moreover, closed-form methods are preferable for at least two reasons: they provide the most meaningful answer because they permit symbolically analyzing the influence of each variable on the result; and their computational cost, in terms of arithmetic operations, is fixed and assessable beforehand. We have actually derived closed-form methods specifically tailored for solving the hand-eye calibration and the point-cloud registration problems which outperform all previous approaches.



4.2 Teaching activities

We are committed to excellence in higher scientific education, through the mentoring of undergraduate, masters and PhD students. Our teaching activity is varied and active. The number of PhD students and PhD theses defended has increased in the last years. Furthermore, we also support students who work in their master theses and final year projects.

UNDERGRADUATE STUDIES:

OUR FACULTY TEACHES UNDERGRADUATE COURSES AT UPC IN:

- **Bachelor in Informatics Engineering, FIB**
- **Bachelor in Industrial Electronics and Automatic Control Engineering, EEBE**
- **Bachelor in Industrial Electronics and Automatic Control Engineering, ESEIAAT**
- **Bachelor in Industrial Technology Engineering, ETSEIB**
- **Bachelor in Industrial Technologies and Economic Analysis, ETSEIB**
- **Bachelor in Biomedical Engineering, EEB**
- **Bachelor in Chemical Engineering, EEBE**
- **Bachelor in Electrical Engineering, EEBE**
- **Bachelor in Energy Engineering, EEBE**
- **Bachelor in Materials Engineering, EEBE**
- **Bachelor in Mechanical Engineering, EEBE**
- **Bachelor in Telecommunications, Technologies and Services Engineering, ETSEIB**
- **Bachelor in Aerospace Technology Engineering, ESEIAAT**
- **Bachelor in Aerospace Vehicle Engineering, ESEIAAT**
- **Bachelor in Architecture, ETSAB**
- **Bachelor in Data Science and Engineering, FIB**
- **Bachelor in Audiovisual Systems, ESEIAAT**
- **Bachelor in Mathematics, FME**
- **Centre de Formació Interdisciplinària Superior (CFIS), FME**

OTHER UNIVERSITIES:

- **Bachelor in Computer Engineering, UPF**
- **Bachelor in Mathematical Engineering in Data Science, UPF**
- **Bachelor in Audiovisual Systems Engineering, UPF**
- **Bachelor in Mechatronics Engineering, UVIC-UCC**

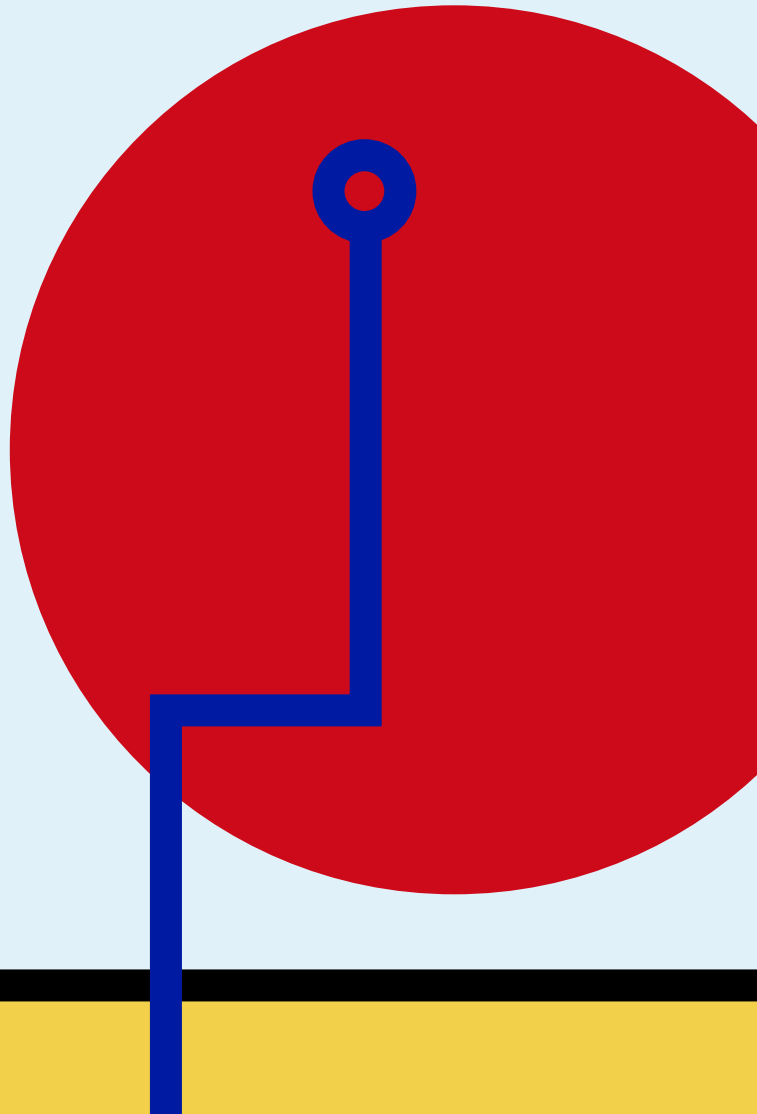
MASTER STUDIES:

OUR POSTGRADUATE TEACHING ACTIVITIES AT UPC ARE INCLUDED IN:

- Master in Automatic Control and Robotics, ETSEIB
- Master in Industrial Engineering, ETSEIB
- Master in Mechanical Engineering and Industrial Equipment, UPC School
- Master in Energy Engineering ETSEIB
- Master in Artificial Intelligence, FIB
- Master in Interdisciplinary & Innovative Engineering, EEBE
- Master in Telecommunication Engineering, ETSETB
- Master in Advanced Telecommunication Technologies, ETSETB
- Master in Automotive Engineering, ETSEIB
- Master in Computer Vision UPF/UAB/UPC/UOC
- Master in Advanced Mathematics and Mathematical Engineering (MAMME)

OTHER UNIVERSITIES:

- Master en Dirección de Empresas Inmobiliarias Innovadoras, Escola Sert, COAC
- Master in Architecture & Design Business Management, UIC



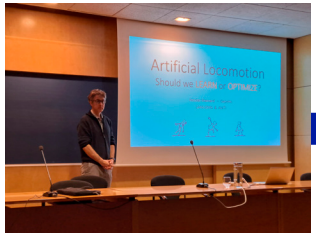
4.3 IRI seminars

Throughout the year IRI holds a series of invited seminars and lectures, featuring invited speakers and our own researchers presenting the results of their work prior to attending international conferences or in preparation of their PhD defence. Here is a selection of the most highlighted seminars.

- 14 June 2021, **José Luis Calvo,** Professor of Systems engineering and automation at Universidade da Coruña (Spain), *"Novel intelligent techniques for optimizing and control of real systems"*
- 15 September 2021, **Nadia Yousfi Steiner,** Professor at the University of Franche-Comté and Researcher at FEMTO-ST Institute (France), *"Towards resilient fuel cell systems"*
- 7 October 2021, **Daniele Astolfi**, CNRS Researcher at LAGEPP (France), *"On the use of dynamic saturation and dead-zone in observer design and synchronization problems"*
- 8 October 2021, **Thomas Flayols**, Support team at I2C Instrumentation design and Characterization, LAAS-CNRS (France), *"The Open Dynamic Robot Initiative"*
- 17 October 2021, **Nicanor Quijano**, Professor at Universidad de los Andes (Colombia), *"Von Neumann Meets the Nexus Problem"*
- 21 April 2022, **Jakub Mozaryn**, Assitant Professor at the Institute of Automatic Control and Robotics, Warsaw University of Technology (Poland), *"Design of Digital-Twin based Test-Bed for Evaluation of Benchmarks for Industrial, Cyber-Physical Systems"*
- 13 July 2022, **Gonzalo Ferrer**, Associate Professor, Head of the Mobile Robotics Laboratory at Skolkovo Institute of Science and Technology (Russia), *"Mobile Robotics: Planning and Perception"*

- 21 September 2022, **Miquel Domènech,** Director of the Department of Social Psychology at Universitat Autònoma de Barcelona (Spain), *"Métodos cualitativos para el estudio de la interacción humano-robot"*
- 28 September 2022, **Ville Kyrki**, Professor at Aalto University (Finland), *"Ingredients for learning to control complex physical systems"*
- 1 December 2022, **Freek Stulp**, Head of the Department of Cognitive Robotics at DLR (Germany), *"Robotic Reinforcement Learning: Hunting the Thimble?"*
- 2 December 2022, **Moghadam Peyman,** Embodied AI Cluster Leader CSIRO and Professor at Queensland University of Technology (Australia), *"3D Geometry meets Learning"*
- 9 January 2023, **Joaquim Ortiz,** Robotics Research Scientist at Keybotic (Spain), *"A Bidirectional Interface between Nonlinear Optimization and Symbolic Planning for Task and Motion Planning"*
- 19 January 2023, **Elizabeth Sklar,** Professor in Agri-Robotics at the University of Lincoln and is also a Professor of Robotics in the Department of Engineering at King's College London (UK), *"Collaborative Robotic Systems for Sustainable Food Production"*

- *17 May 2023,* **Pedro Fornaro,** *Postdoctoral researcher at National University of Ireland Maynooth and Universidad Nacional de La Plata (Argentina), "Parameter estimation based on algorithms by sliding modes. Application to redox flow batteries"*
- *18 May 2023,* **Daniele Astolfi**, *Researcher at CNRS (France), "Robust periodic output regulation for nonlinear systems and repetitive control"*
- *24 May 2023,* **Mark Coeckelbergh,** *Professor of Philosophy of Media and Technology at the University of Vienna (Austria), "AI and the principles of democracy"*
- 27 June 2023, **Victor Sanchez-Anguix**, Professor at the School of Informatics, Universitat Politècnica de València (Spain), *"Cooperating in the face of conflict: Heuristic-based automated negotiation"*
- 10 October 2023, **Fadel Adib**, Associate Professor at MIT (USA), *"Decoding Hidden Worlds: Unprecedented Sensing and Connectivity for Climate, Robotics, & Smart Environments"*
- 21 November 2023, **Tim Bretl**, Associate Professor of Aerospace Engineering and a Research Associate Professor in the Coordinated Science Laboratory, University of Illinois (USA), *"Mechanics, Manipulation, and Perception of Deformable Objects"*
- 29 April 2024, **Nicolas Mansard**, Researcher at LAAS- CNRS (France), *"Artificial movement: Should we learn or optimize?"*



- 17 June 2024, **Bernard Bayle**, Professor at the University of Strasbourg - ICube laboratory (France), *"Contributions to Physical Human-Robot interaction"*
- 16 July 2024, **Hsien-I Lin**, Professor at the Institute of Electrical and Control Engineering, National Yang Ming Chiao Tung University (Taiwan), *"Paradigms of Intelligent Industrial Robots"*

4.4 SUMMER SCHOOL

We have successfully organized the **Robotics and AI Summer School** every year from **2020 to 2024**, offering a vibrant learning experience for students and early-stage researchers. The first four editions (2020–2023) were held **online,** allowing us to connect with participants from all over the world despite the challenges of the pandemic. In **2024**, we were thrilled to finally host the school **on-site**, bringing together the community in person for the first time. Each edition has been a fantastic opportunity to share knowledge, build connections, and explore cutting-edge topics in robotics and artificial intelligence — and we're proud of how much it has grown!

- **Robotics & AI *(2nd Edition)*:**
  28-30 June, 2021, ONLINE,
  N. of attendants: 85
- **Robotics & AI *(3rd Edition)*:**
  4-6 July, 2022, ONLINE,
  N. of attendants: 115
- **Robotics & AI *(4rd Edition)*:**
  10-12 July, 2023, ONLINE,
  N. of attendants: 43
- **Robotics, Control Systems & AI *(5th Edition)*:**
  3-5 July, 2024, ON-SITE,
  N. of attendants: 31

05

TECHNOLOGY TRANSFER

ACCIÓ Catalonia Trade & Investment · Generalitat de Catalunya
tecnio catalonia
Vigència: 29/12/2028

Through agreements with industrial partners, we promote the transfer of the Institute's achievements on excellence research to practical applications.

One of the main objectives for the Institute is to foster collaboration and find common solutions between industry needs and our research. As a result, IRI holds the **TECNIO accreditation**. This seal, granted by the Catalan Government, recognises differential technology providers actively engaged in the technology transfer process.

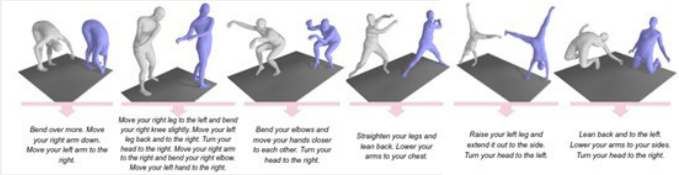
TECHNOLOGY TRANSFER PROJECTS DURING THE PERIOD 2021-2024:			
Ongoing contracts: 37 contracts 27 different companies	**Received funds:** 998.254,65	**Protection:** 2 patent applications 5 software registrations	**Spinoff companies:** 1 new company 1 company (in process) 1 ongoing company

5.1 Tech transfer Contracts

Below, we detail a selection of the most notable contracts during the period ordered by its budget.

Tex4Pose: Leveraging text to improve human pose, shape, motion estimation and generation. Francesc Moreno.

The goal of the project is to study how text information can be leveraged in order to improve problems related to human pose: estimating human pose and shape in images or in videos, as well as predicting future human motion. This project is a collaboration between IRI and Naver Labs Europe.



- **IRI Leader:** Francesc Moreno
- **Period:** September 2021 - September 2024
- **IRI Budget:** 154 500 €
- **Company involved:** Naver Labs Europe

GEPEVE: Gestión predictiva de energía para eficiencia energética en vehículos eléctricos con control de crucero adaptativo

We were contracted by the company Ficosa ADAS in the "MOBILITY 2030" project under the Misiones-CDTI initiative for the development of an efficient energy control module for vehicles. This module utilized external vehicle perception and data about the condition of the electric batteries to generate optimal acceleration and regenerative braking ratios, enhancing battery performance.

- **IRI Leader:** Juan Andrade
- **Period:** July 2021 - July 2023
- **IRI Budget:** 99 800 €
- **Company involved:** Ficosa ADAS

CETAQUA: Contribució a la promoció i supervisió de projectes de recerca de l'àmbit de les xarxes de distribució d'aigua

Agbar, in collaboration with the UPC and CSIC, established CETaqua, the Water Technology Centre. Its shared objective is to promote, conduct, disseminate, and transfer research, technological development, and innovation in the comprehensive water cycle management. Their aim is to offer businesses, society, and Public Administrations innovative solutions for addressing environmental and technological challenges associated with the integrated water cycle management.

- **IRI Leader:** Gabriela Cembrano
- **Period:** June 2007 - May 2024
- **IRI Budget:** 657 000 €
  (54 000 € in 2021-2024)
- **Company involved:** CETAQUA

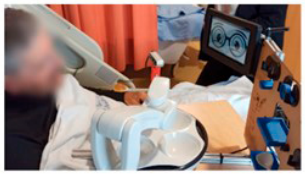
MAPRICOM: Suport i desenvolupament d'un sistema de manteniment predictiu

The MAPRICOM project aims to create an autonomous system for predicting the Remaining Useful Life (RUL) of any mechanical component. It will collect data from sensors on dispensing equipment, store it in a unified structure, and autonomously organize it into specific tables for each component type. The system will label this data and calculate the RUL for components with past failures. A failure is identified when a component stops functioning and is subsequently replaced by another of the same type on the same equipment. This project is a collaboration with DATISION under the 2021/C005/00152974 grant for AI and digital technology research and development.

- **IRI Leader:** Guillem Alenyà
- **Period:** February 2023 - April 2023
- **IRI Budget:** 50 000€
- **Company involved:** Datision

PIONEER: Projecte Innovador OrieNtat a dissEnyar l'atEnció soclosanitària del futur, Guillem Alenyà.

Research and development project with the objective of improving the autonomy of elderly and/or dependent individuals in the feeding process. This project seeks to develop technology so that these individuals can eat by themselves without needing constant assistance from another person.



- **IRI Leader:** Guillem Alenyà
- **Period:** November 2023 - February 2025
- **IRI Budget:** 41 257,17 €
- **Company involved:** Parc Sanitari Pere Virgili

HELIPORTS: Desarrollo de soluciones de visión por computador para la gestión de helipuertos y aeródromos

This project will provide support in the development of methods related to the management of aircraft within a heliport, with the following objectives:

Objective (1): Identification of the model of different aircraft as well as their registration number.

Objective (2): Identification of objects on the airfield and trajectories of people, animals, or other elements that may invade the airspace.

- **IRI Leader:** Jordi Sánchez
- **Period:** May 2021 - November 2021
- **IRI Budget:** 20 000 €
- **Company involved:** ITOR MARTIN

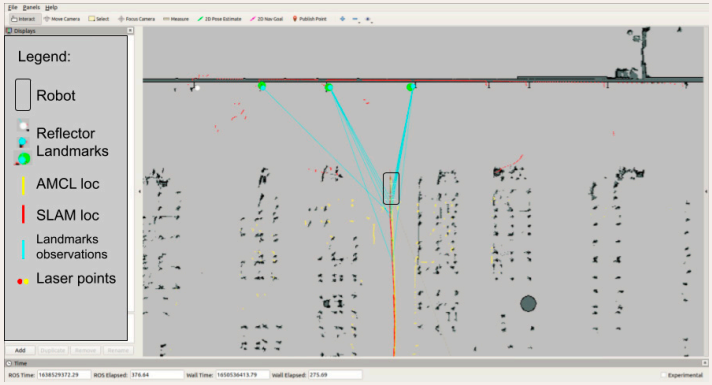
CARNET

During the 2021-2024 period, a series of tech transfer contracts were maintained with the CARNET Future Mobility Research Hub for the development of software and hardware solutions for mobile robotic navigation in urban areas, and for the technical support in the organization of a number of autonomous driving challenges.

- **IRI Leader:** Alberto Sanfeliu
- **Period:** July 2017 - October 2023
- **IRI Budget:** 185.750 € (in the period)
- **Company involved:** CIT UPC

DOGS: Development of an AGV Guiding System + DOGS2: Development of an IMU aided AGV Guiding System

In this series of tech transfer projects, we addressed the need of the company Artisteril to improve the location and navigation capabilities of AGVs in an application of the automotive sector. We developed software solutions for them.



- **IRI Leader:** Juan Andrade
- **Period:** November 2020 - February 2021 / July 2021 - April 2022
- **IRI Budget:** 16 110 € + 16 110 €
- **Company involved:** Artisteril

NODELAB + NODELAB II: Acuerdo para la realización de una prueba de concepto sobre metodología y conocimiento de detección de fugas (segunda fase)

- **IRI Leader:** Gabriela Cembrano
- **Period:** June 2021 - December 2021 / February 2024 - August 2025
- **IRI Budget:** 11 000 € + 18 000 €
- **Company involved:** Suez Spain + SGAB

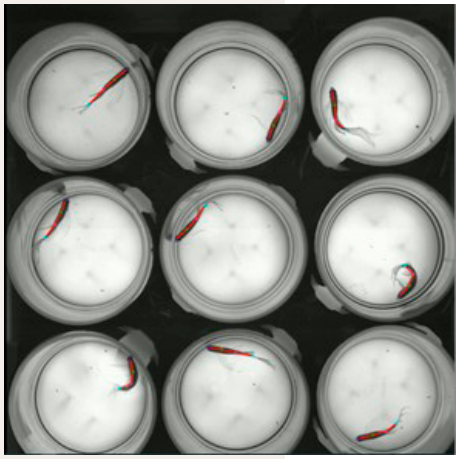
PIPPO: Fast kinematics for a parallel robot + PIPPO+: Learning the kinematics of a parallel robot

In these projects, new closed-form solutions and solutions based on machine learning were developed for the forward and inverse kinematics problems of a parallel robot from the company OMRON.

- **IRI Leader:** Josep Maria Porta
- **Period:** April 2022 and March 2023
- **IRI Budget:** 9 600 € + 9 600 €
- **Company involved:** Omron Electronics Iberia

AquaLight: Mejora de la iluminación del ZebraCam) + AquaShake: Mejora del sistema de vibración del ZebraCam

In these projects, a device previously developed by our group to analyze the behavior of zebrafish subjected to vibrational stimuli was improved. This device is very useful for detecting the effect of chemical substances on zebrafish, which are one of the model animals from which the possible effects of these substances on human beings can be inferred.



- **IRI Leader:** Josep Maria Porta
- **Period:** January 2022 - May 2022 / May 2022 - February 2023
- **IRI Budget:** 3000 € + 9 000 €
- **Company involved:** IDAEA, CSIC

5.2 Patents and licenses

During the 2021-2024 period, IRI researchers participated in the filing of these patents:

- **S. Foix, J. Oriol, J. Borràs, P. Grosch;** "Gripper and procedure for the separation of layers"; CSIC: 100%; EU patent Application EP24382974.4, Filing date: 12/09/2024
- **F. Moreno-Noguer, G. Alenyà, E. Corona, A. Pumarola, G. Rogez;** "Method for determining a grasping hand model"; Naver Labs Europe: 50%, CSIC: 25%, UPC: 25%; U.S. patent Application (U.S Non-Provisional Appl. S.N. 17/341970 and U.S. Provisional Appl.S.N. 63/208,231), Filing date: 08/06/2021

Regarding licensing, several software developments has been registered or licensed:

- **A. Sanfeliu Cortés, À. Santamaria Navarro;** "Simulador de plataforma robòtica Ona 1"; UPC: 100%; Software Registration 2402146930612, Registration date: 14/02/2024.
- **A. Sanfeliu Cortés, À. Santamaria Navarro;** "Simulador de plataforma robòtica Ona 1"; UPC: 100%; Software Registration 2402146930612, Registration date: 14/02/2024.
- **J. Sánchez Riera;** "Navegación autònoma de plataforma robòtica"; Biel Glasses: 50%, CSIC: 25%, Leitat: 25%; Know-How Agreement and Licensing of Results from the project "SMARTGAZE II" to Biel Glasses, S.L., License date: 27/10/2023.
- **F. Moreno Noguer;** "Algoritmo para la estimación de medidas del cuerpo humano a partir de imagen"; CSIC: 100%; Software Registration 105745Z, Software Registration date: 19/05/2022, License to Vody Technological Solutions, S.L. (IRI spinoff), License date: 22/09/2023.
- **F. Moreno Noguer, G. Alenyà Ribas, E. Corona Puyane, A. Pumarola Peris, G. Rogez;** "Method for determining a grasping hand model"; Naver Labs Europe: 50%, CSIC: 25%, UPC: 25%; Exclusive Rights Sale of Spanish Patent P202030553 to Naver Labs Europe, Sale date: 05/04/2022.

5.3 Spin-off companies

VODY

Vody Technological Solutions S.L.; Company creation date: 28/02/2023, **Participation: F. Moreno; License contract signature: 27/09/2023**

VAIVE LOGISTICS

Vaivé Logistics S.L.; Company creation date: 16/02/2023, **Participation: A. Sanfeliu, À. Santamaría, and F. Herrero;** Note: The license contract is currently under negotiation

datision

Datision; Company creation date: 25/07/2018 **Participation: G. Alenyà and S. Foix. License contract signature: 03/07/2019**

5.4 Expertise

MECHANISM DESIGN & ANALYSIS

Mechanism design and construction.
Molecular modelling.
Planning of mechanism motion.

AERIAL ROBOTICS

Localization, mapping and navigation.
Perception and manipulation.
Control and planning strategies.

SOCIAL ROBOTICS

Robot companions.

ASSISTIVE ROBOTICS

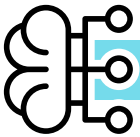
Proactive assistance to disabled users.
Perception and manipulation of objects.

URBAN MOBILITY

Autonomous navigation.
Driving assistance (ADAS).
Urban service robotics.
Heavy vehicle automation.

ENERGY SYSTEMS

Fuel cell systems.
Energy management.



VISUAL PERCEPTION

Deep learning applications.
Geometric computer vision.

COMPLEX SYSTEMS CONTROL

Modelling, control and supervision
of complex systems.

SMART FACTORIES

Human-robot cooperation.
Factory automation.

WATER CONTROL SYSTEMS

Drinking waters networks.
Urban drainage systems.

5.5 Services and clients

SERVICES OFFERED TO COMPANIES

01 INNOVATIVE RESEARCH PROJECTS

Answers to singular needs at the state of the art, providing solutions with added value.

02 INDUSTRIAL DOCTORATES

Supervision of company-hired or grant-supported industrial PhD students

03 CONSULTING

Industrial and technical advice to companies to help them develop new products and services.

04 PARTICIPATION IN PROJECT CONSORTIA

We often take part in collaborative projects and initiatives participated by industrial partners with national and international competitive funds.

05 USE OF LABORATORY EQUIPMENT

Facilities are open to our industrial collaborators for project development.

06 PROTOTYPING

Design, rapid prototyping and testing of devices to address specific needs.

OUR COLLABORATORS AND CLIENTS

OUTREACH 06

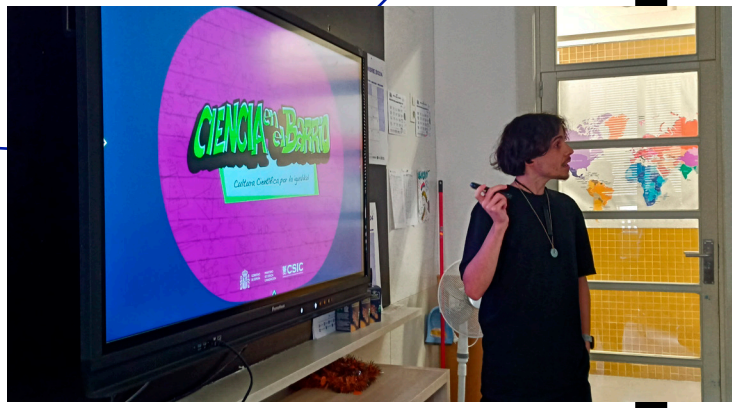
6.1 Activities

WHY?

At IRI, we think that it is good to involve all our members in scientific dissemination activities that attempt to bring our science to all audiences. For this reason, our staff participates frequently in many events such as seminars, workshops, talks, exhibitions and competitions. It is our commitment to society.

OUTREACH ACTIVITIES

- **Dia de la Ciència a les Escoles** (2021)
- **Barcelona Woman Acceleration Week** (2021)
- **Jornadas SCM. Institut d'Estudis Catalans** (2021)
- **EduCaixaTalks STEAM** (2021)
- **KOSMOPOLIS** (2021)
- **St Jordi UPC** (2021, 2024)
- **Biennal Ciutat i Ciència** (2021, 2023)
- **Festival 42** (2021, 2023)
- **Women in Science** (2022)
- **Mobile Week 2022, BCN Pensa** (2022)
- **Fira de la recerca del BCN, Pensa** (2022)
- **Brain Film Fest** (2022)
- **TEDxEixample** (2022)
- **Argumenta BCN** (2022)
- **Bojos per la ciència** (2022, 2023, 2024)
- **Exhibition Científiques 2.0** (2022)
- **Festa de la Ciència** (2023, 2024)
- **La Marató: "Visita la recerca de La Marató"** (2023)
- **Setmana de la Ciència** (2023, 2024)
- **La Nit de la Recerca** (2024)
- **Manifesta 15 Barcelona Metropolitana 2024** (2024)
- **International Day of Women in Science** (2021, 2022, 2023,2024)


CIÈNCIA al BARRI
Cultura Científica per tothom
CSIC


Descobreix els
ROBO-CIENTÍFICS


LabORA


16a Festa de la Ciència
22
ALGORITMES ARTÍSTICS
22
ALGORITMES ARTÍSTICS
22
LabORA

6.2 Social and Media

SOCIAL NETWORKS

In order to better engage with society through current technologies, we decided to join social media platforms. Since 2011, we have maintained a presence on Twitter (now X), YouTube, LinkedIn, and our institutional website. More recently, in February 2025, we opened a Bluesky account in response to the ongoing controversies surrounding Twitter (X).

We use our social media channels to publish job offers, share information about our research seminars, and announce the international visitors we host. We also post about our participation in outreach events, daily activities at the centre, and news and curiosities related to robotics. In addition, our YouTube channel is primarily used by our researchers to share videos of their demonstrations and ongoing work.

LinkedIn: IRI - Institut de Robòtica i Informàtica Industrial

Twitter (X): @IRI_robotics

Bluesky: @iri-robotics.bsky.social

YouTube: institutderobotica

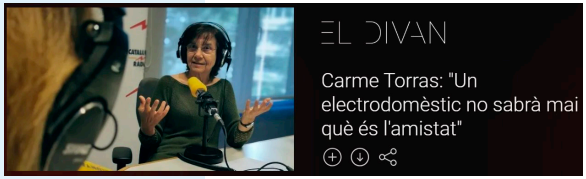
Web: www.iri.upc.edu

MEDIA APPEARANCES

MEDIA APPEARANCES
473 NEWSPAPERS AND MAGAZINES
34 TELEVISION PROGRAMMES
35 RADIO PROGRAMMES

During the period 2021-2024, the presence of IRI in the media has been remarkable, appearing in several newspapers, television and radio programs.

RADIO



PRESS

ara

ARA MATEIX

Recerca

Bonaventura Clotet i Carme Torras guanyen el Premi Nacional de Recerca 2020

Bonaventura Clotet i Carme Torres guanyen el Premi Nacional de Recerca. ARA

1 min

El Govern i la Fundació Catalana per a la Recerca i la Innovació han guardonat *ex aequo* amb el Premi Nacional de Recerca 2020, valorat en 40.000 euros, el metge i infectòleg de Can Ruti Bonaventura Clotet i la matemàtica especialista en robòtica i intel·ligència artificial (IA) Carme Torras.

LA VANGUARDIA

MOVILIDAD Y LOGÍSTICA

De la ciencia al mercado: el vehículo autónomo a prueba

• El prototipo de plataforma robotizada de reparto creada por la UPC, el 'hub' Carnet y el IRI afronta sus primeros ensayos en espacios públicos

Las pruebas se llevaran a cabo en Esplugues, Hamburgo y Debrecen (UPC)

JOAQUIM ELCACHO

Hacer más ágil y eficiente la distribución de productos se ha convertido en uno de los grandes retos en entornos urbanos. Una de las alternativas con mayor futuro es la automatización o robotización de las entregas a distancias cortas.

Un equipo de la Universitat Politècnica de Catalunya (UPC), el *hub* de investigación sobre movilidad Carnet y sus socios industriales, coordinados por el Institut de Robòtica i Informàtica Industrial (IRI), ha presentado y pondrá a prueba este mismo año un prototipo de robot autónomo que aspira a revolucionar la logística de última milla, como se conoce este

europa press

El primer 'Living Lab' catalán crea un robot que ayuda a comer a pacientes que no pueden hacerlo solos

Prototipo de robot desarrollado para dar de comer a pacientes m...

Ver en YouTube

Europa Press Catalunya

Newsletter

El prototipo "aún no es industrializable" y facilitará la tarea a cuidadores

BARCELONA, 26 Oct. (EUROPA PRESS) -

Instituciones catalanas han impulsado la plataforma Barcelona Aging coLLaboratory (BALL), el primer 'Living Lab' en Catalunya que tiene como objetivo crear soluciones centradas en el envejecimiento de la población, y ha presentado su primer proyecto que es un "robot humanizado" que ayudará a pacientes que no pueden alimentarse por sí mismos.

La iniciativa se ha presentado este miércoles en una rueda de prensa en el Parc Sanitari Pere Virgili de Barcelona, que es la sede física del BALL, y que surge con la finalidad de "aportar soluciones innovadoras a las personas mayores", en el marco de una población que cada vez es más

SER.100

Borrissol, Nyam i Sòcrates: els robots assistencials del futur

L'Institut de Robòtica i Informàtica Industrial desenvolupa, des de Barcelona, robots dissenyats per cuidar i ajudar les persones

REPORTATGE: Robots que cuiden

Roger Arnau

En Borrissol és un dels robots que l'Institut de Robòtica i Informàtica Industrial (IRI) està desenvolupant el seu laboratori de percepció i manipulació de Barcelona. L'objectiu és crear la tecnologia necessària, també a través de la intel·ligència artificial, perquè els robots assistencials –és a dir els robots que ajuden les persones– siguin una realitat. En Borrissol és un robot petit, no arriba al metre d'alçada, que l'IRI està desenvolupant juntament amb l'Institut Català d'Oncologia (ICO). Bàsicament, acompanya els pacients, els ajuda a fer determinats exercicis físics i calcula quin és el seu grau de fragilitat física.

"La idea és que el robot el pugui venir a buscar a la sala d'espera de la consulta del metge, l'acompanyi a una sala i sigui el mateix robot qui vagi guiant, observant i mesurant els exercicis que cal fer". Guillem Alenyà, director de l'IRI, explica com les dades que recull en Borrissol, per exemple, quan el pacient camina o s'aixeca d'una cadira, ajuden als metges de l'ICO a tractar i diagnosticar millor els medicaments.

Lo más leído

Montilla sobre la dana: "Si hubiera sido presidente no habría llegado a esta situación, cuando ves que no tienes los medios los tienes que pedir"

"Des del Madrid treballem per la situació

RAC1

La competència

Sota, el petit robot que arriba a Catalunya per estudiar com interaccionem amb els androides

El robot atendrà els pròxims dies els estudiants de la Universitat Politècnica de Catalunya que vagin al bar de la facultat de Matemàtiques

Sota, el petit robot que arriba a Catalunya per estudiar com interaccionem amb els androides

RAC1

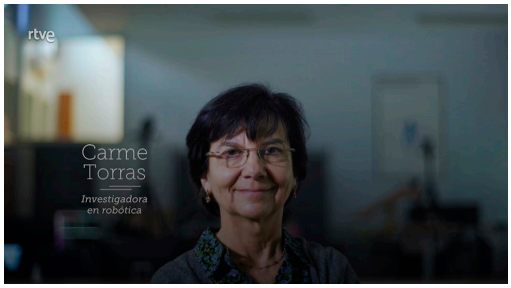
Un robot atendrà en els pròxims dies els estudiants de la **Universitat Politècnica de Catalunya** que vagin al bar de la facultat de Matemàtiques. L'androide ela oferirà promocions, descomptes o nous productes. Es tracta d'una prova pilot per veure **com els humans interaccionem amb els androides**, en un experiment que està impulsat pel govern del Japó.

TELEVISION

rtve

CULTURA

El científic i doctor enginyer industrial Pablo Jiménez parla sobre robòtica a l'Aula de Cultura



rtve

Carme Torras

Investigadora en robòtica

betevé

Alberto Sanfeliu
investigador Institut Robòtica Informàtica Industrial (IRI)

DIRECTE Barcelona

ROBOTS QUE AJUDEN

Sergi Foix
investigador del CSIC a la UPC

TITULARS

09:52

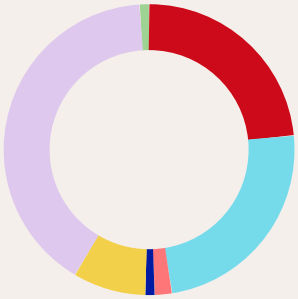
FUNDING

07

Funding sources of our center are diverse. CSIC and UPC finance salaries of permanent staff belonging to these institutions. In addition, CSIC and UPC also make contributions for general operating expenses of the institute.

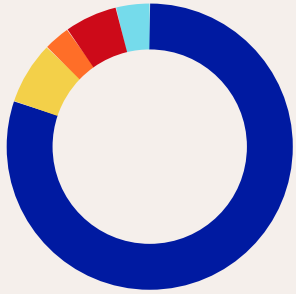
Our scientific personnel are committed to excelence in research, and that is why half of our budget is obtained through competitive calls for projects and personnel programmes, as well as technology transfer contracts.

BUDGET 2021-2024

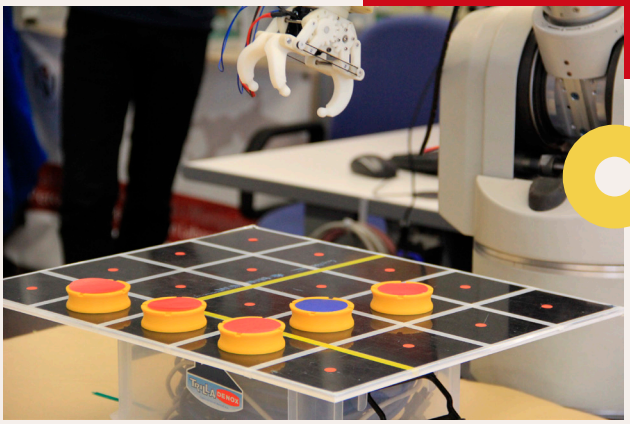


- CSIC General budget: 23%
- UPC General budget: 25.18%
- CSIC specific funding: 1.26%
- UPC specific funding: 0.26%
- Competitive personnel programs: 8.61%
- Project and contract funds: 41,25%
- Other income: 0.45%

EXPENSES 2021-2024



- Personnel: 80.33%
- General running expenses: 7,05%
- Scientific equipment: 2,87%
- Other project expenses: 5.92%
- Overheads: 3,83%



SEE YOU SOON

L'IRI és un centre que està sempre en constant creixement i transformació. Això per nosaltres és molt positiu, ja que indica que som un centre viu i amb capacitat per adaptar-se als ràpids canvis i realitats de la nova societat tecnològica.

A l'IRI formem els nostres joves investigadors amb excel·lència. Estem molt satisfets que, tant els que han optat per l'àmbit empresarial com els que han seguit el camí acadèmic, rebin reconeixement internacional i contribueixin a ampliar l'impacte del nostre institut. En aquest sentit, estem engegant noves iniciatives per mantenir vius els vincles de la comunitat IRI.

Tenim el repte de continuar essent un referent internacional. Amb aquesta idea, a l'inici d'aquest nou període estem impulsant la creació d'una nova oficina de promoció internacional que faciliti als nostres investigadors i investigadores que la seva recerca tingui un impacte més internacional.

El nostre pla estratègic inclou una voluntat ferma en incrementar l'impacte en el teixit local a través de dues vies. En primer lloc, vehicular l'impacte mitjançant processos de cocreació, treballant en equips multidisciplinaris i fomentant espais i projectes on diversos actors de la societat col·laborin per apropar la nostra recerca a la ciutadania. En segon lloc, organitzar xerrades per al públic general, promoure debats sobre robo-ètica i difondre idees sobre com afrontar el futur digital i tecnològic que ens espera.

The IRI is a centre that is always growing and changing. This is very positive for us, as it indicates that we are a living centre with the capacity to adapt to the rapid changes and realities of the new technological society.

At IRI we train our young researchers with excellence. We are very pleased that both those who have opted for business and those who have followed the academic path receive international recognition and contribute to broadening the impact of our institute. In this regard, we are launching new initiatives to keep the links of the IRI community alive.

We have the challenge of continuing to be an international benchmark. With this in mind, at the start of this new period we are promoting the creation of a new international promotion office that will help our researchers to ensure that their research has a more international impact.

Our strategic plan includes a firm will to increase the impact on the local fabric through two channels. Firstly, to convey the impact through co-creation processes, working in multidisciplinary teams and promoting spaces and projects where various actors in society collaborate to bring our research closer to the public. Secondly, organising talks for the general public, promoting debates on robo-ethics and disseminating ideas on how to face the digital and technological future that awaits us.

IRI
REPORT

2021-2024

Institut de Robòtica i Informàtica Industrial

CSIC

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH