ISTITUTO ITALIANO
DI TECNOLOGIA

STRATEGIC PLAN 2024-2029

RESEARCH UNITS AND FACILITIES

ISTITUTO
ITALIANO DI
TECNOLOGIA

Table of Contents

RD: Computational Sciences

Research Units

Principal Investigators

QUANTUM MATERIALS THEORY

Principal Investigator

Sergey Artyukhin

CCT@Morego

Description

Our interests are in realistic modelling of quantum effects in magnetic, ferroelectric, multiferroic, and other functional materials. We use analytical and computational tools to study magnetic, electronic, and optical effects. Materials have defined the development of civilization, thus giving their name to historical epochs. Ferroic materials are of immense fundamental and technological interest. For example, most information is stored today using magnetic materials.

But when the existing technology struggles against its limits (e.g. Moore law), then the world needs devices based on new physical principles to enable superior performance, information density, and energy efficiency. We discover new physics by modelling quantum materials and interpreting puzzling data from our experimental colleagues to find out how quantum physics endows materials with new useful properties and functionalities. Our work combines analytical and numerical calculations, including first-principles modelling.

Achievements

The team has established the paradigm of topological switching in ordered materials. We found the first topologically protected switching process in $GdMn_2O_5$ (Nature, 2022). We also found that topology controls the switching dynamics in spiral magnets.

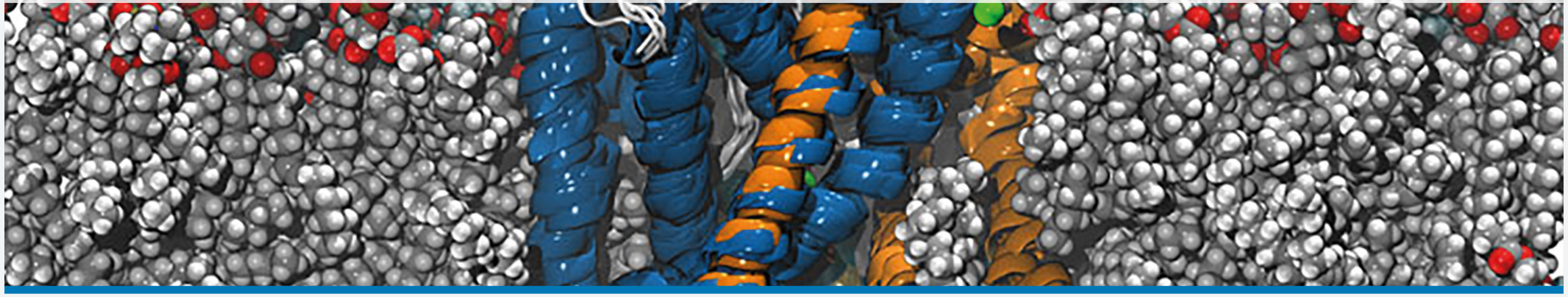
Our earlier achievements include:

i. Explaining elastic softening near ferroelectric domain walls;
ii. Formulating a theory of scanning microwave spectroscopy in ferroelectrics; and
iii. Studying ultrafast dynamics in dimerized states of $IrTe_2$, spin density waves in Cr and ultrafast thermal transport in GaV_4S_8, among other effects.

Representative Publications

[1] Sekiguchi F. et al., Nature Communications, vol. 13, (no. 1), 2022.
[2] Ponet L. et al., Nature, vol. 607, (no. 7917), pp. 81-85, 2022.
[3] Zhao H.J. et al., Nature Materials, vol. 20, (no. 3), pp. 341-345, 2021.
[4] Ideta S.-I. et al., Science advances, vol. 4, (no. 7), 2018.
[5] Wu X. et al., Science advances, vol. 3, (no. 5), 2017.

COMPUTATIONAL AND CHEMICAL BIOLOGY



Principal Investigator
Andrea Cavalli
CHT@Erzelli

Description

We develop innovative methods to identify and validate novel targets for drug discovery. Our experimental and computational approaches range from genome sequencing to free energy measures and simulations based on statistical mechanics and machine learning. For example, we may start by identifying gene variants (e.g. SNP, structural variants) responsible for cancer onset and progression in oncology patients. We then study these variants in an actionable gene approach to personalized medicine.

Here, we use drug repurposing to provide an immediate benefit to patients. In parallel, we may conduct AI-driven structural genomics, using AI and machine learning (e.g. AlphaFold, ESMFold, AlphaMissense) to construct a 3D model of the wild-type and mutated proteins, and to predict the impact of mutations. We then exploit the results using computational drug discovery, a field in which we have developed innovative approaches.

Achievements

From clinics to drug repurposing and discovery, we have built an entire pipeline of activities that begin with patients, move through computational methods (AI, ML, and physics-based approaches), and return to patients with the identification of personalized therapeutics or new drug candidates for primary unmet medical needs.

This pipeline can be summarized as patient-genes-proteins-actionable genes-drug repurposing/discovery-patient. A final word on synthetic lethality, which is the central paradigm of our strategies for combating pancreatic cancer and other oncological conditions.

Representative Publications

[1] Wranik M. et al., Nature Communications, vol. 14, (no. 1), 2023.

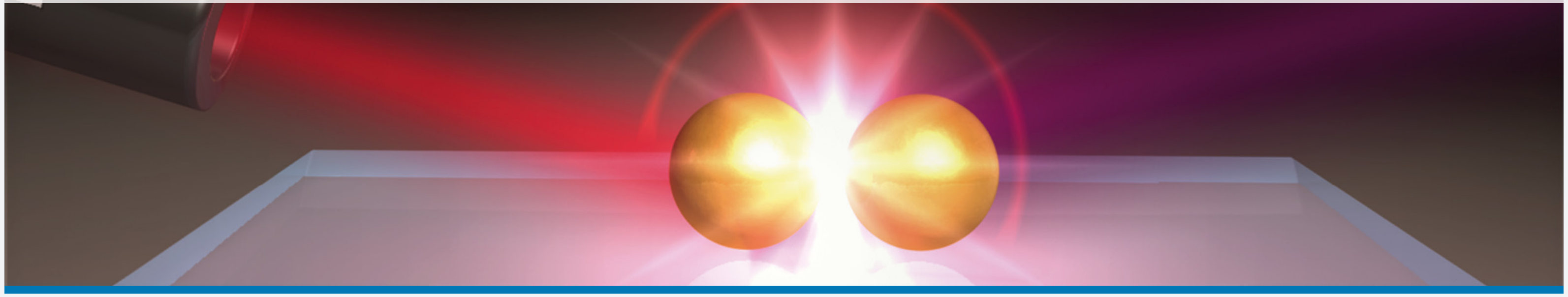
[2] Muhlethaler T. et al., Angewandte Chemie - International Edition, vol. 61, (no. 25), 2022.

[3] Decherchi S. et al., Chemical Reviews, vol. 120, (no. 23), pp. 12788-12833, 2020.

[4] Schiebel J. et al., Nature Communications, vol. 9, (no. 1), 2018.

[5] Decherchi S. et al., Nature Communications, vol. 6, 2015.

COMPUTATIONAL NANOPLASMONICS



Principal Investigator
Cristian Ciracì
CBN@UniLe

Description

We numerically investigate physics-driven applications by leveraging interactions between photons and electrons at nanometer scales. Our focus is plasmonic systems, nonlinear optics, and quantum effects.

Under certain conditions, light incident on a metallic particle can excite a collective electron excitation known as a surface plasmon-polariton (SPP). This term describes the nature of the interaction, which involves the metal's free electrons (plasma) and light-induced polarization (polariton). SPPs can confine the electromagnetic energy to arbitrarily small volumes, making the light "sensitive" to the subatomic realm. In this regime, the classical description of light-matter interactions is not sufficiently accurate because quantum mechanical effects cannot be neglected.

We aim to develop novel numerical tools and theoretical methods to tackle light-matter interaction problems that take into account quantum microscopic features at the scale of billions of atoms.

Achievements

We have pioneered the development of the quantum hydrodynamic theory beyond the gradient approximation of the kinetic energy functional. Our work has thus provided a tool to account for electron spill-out and optical quantum tunneling through macroscopic quantities.

We coordinate an EU Pathfinder project to exploit free-carrier optical nonlinearities in heavily doped semiconductors for integrated all-optical devices.

Our research results have been published in several international high-impact peer-reviewed journals.

Representative Publications

[1] De Luca F. et al., Physical Review Letters, vol. 129, (no. 12), 2022.
[2] Baghramyan H.M. et al., Physical Review X, vol. 11, (no. 1), 2021.
[3] Noor A. et al., ACS Photonics, 2020.
[4] Ciraci C. et al., Nanophotonics, vol. 8, (no. 10), pp. 1821-1833, 2019.
[5] Ciraci C.Physical Review B, vol. 95, (no. 24), 2017.

MOLECULAR MODELING AND DRUG DISCOVERY

Principal Investigator
Marco De Vivo
CHT@Erzelli

Description

We study the structure, dynamics, and reactivity of chemical systems by using classical molecular dynamics simulations coupled with first-principles-based computational methods (e.g. quantum mechanics/ molecular mechanics simulations) and enhanced sampling techniques for free energy estimation. This multiscale computational approach also includes docking, virtual screening, de novo small molecule computational design, and in silico ADMET evaluation for drug design.

These computational efforts are integrated with medicinal chemistry and structural/molecular biology to identify and optimize novel small molecules able to modulate the protein function of interest. The goal is to understand the general principles that control molecular recognition and catalysis, and to use this information to design intelligent nanosystems and potent inhibitors for drug discovery. In this regard, we focus on targeting cancer, neurological disorders, and inflammatory-related diseases.

Achievements

Selected achievements include:

i. 2023 ESMEC International Alumni Award – European School of Medicinal Chemistry;
ii. Delegate of the Division of Computational and Theoretical Chemistry, EuChemS since 2023;
iii. Executive Editor of J. Chem. Theory Comput. since 2023;
iv. In 2022, elected Chair of the 2026 Gordon Research Conference in Computational Chemistry;
v. Board Member of the Pharmaceutical Chemistry Division of Società Chimica Italiana since 2021;
vi. Scientific and Technical Committee Member of AIRC, Italy since 2018; and
vii. 2017 ACS COMP Division, Outstanding Junior Faculty Award.

Representative Publications

[1] Jahid S. et al., Cell Reports, vol. 39, (no. 1), 2022.
[2] Manigrasso J. et al., Chem, vol. 7, (no. 11), pp. 2965-2988, 2021.
[3] Franco-Ulloa S. et al., Nature Communications, vol. 11, (no. 1), 2020.
[4] Donati E. et al., Journal of the American Chemical Society, vol. 142, (no. 6), pp. 2823-2834, 2020.
[5] Manigrasso J. et al., Nature Communications, vol. 11, (no. 1), 2020.

PATTERN ANALYSIS AND COMPUTER VISION

Principal Investigator
Alessio Del Bue
CHT@Erzelli

Description

We strengthen IIT's artificial intelligence (AI) activities, with a focus on computer vision. Our goal is to provide assistive AI systems to support humans in their daily life. We do this by analyzing large-scale and multimodal datastreams, particularly those from visual and audio sensor modalities (e.g. cameras).

Our three research areas are:

i. Sensing the 3D structure of generic and unknown scenes, with an emphasis on active vision and 3D reconstruction, enabling robotic and AI agents to understand and interact with the environment;
ii. Unsupervised and self-supervised learning in challenging scenarios with few or no labelled data; and
iii. Multimodal learning to integrate different sources of information from heterogeneous sensor modalities, common-sense information, and physical constraints.

Achievements

We have developed an intelligent sensor network infrastructure at the Center for Human Technologies to deploy, test, and validate human-centric AI approaches in collaboration with several IIT PIs. This infrastructure is used to deploy assistive AI technology. It will be critical to integrating computational and robotics systems for social good and healthcare applications as part of IIT's Strategic Plan.

We collaborate with industry leaders in various economic sectors in Italy and abroad on the technology transfer of AI systems.

Representative Publications

[1] Cavazza J. et al., IEEE Transactions on Pattern Analysis and Machine Intelligence, 2023.

[2] Ahmad S. et al., Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV), 2023.

[3] Zohaib M. et al., Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV), 2023.

[4] Giuliari F. et al., Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition, vol. 2022-June, pp. 19496-19505, 2022.

ATOMISTIC SIMULATIONS

Principal Investigator
Michele Parrinello
CHT@Erzelli

Description

We apply and develop advanced simulation methods that combine molecular-dynamics-based sampling with machine learning algorithms. This combination has enabled the study of systems of unprecedented complexity. It can be applied to problems in fields including material science, biophysics, and chemistry. In particular, we have studied catalytic processes of interest for the transition to the green economy. Our work challenges the traditional vision of these processes, giving new orientation to experiments and stimulating the development of new theoretical and computational tools.

Achievements

Etherogeneous catalysts are the instrument of choice for synthesizing chemical compounds in industry. We have shown that their behavior is strongly affected by the dynamical processes that take place at the surface, in which catalytic centers are continuously formed and broken. The catalysts investigated include iron for the production of ammonia, and some lithium immide compounds that can decompose it.

We have also quantitatively described how water plays a crucial role in the workings of several enzymes.

Representative Publications

[1] Stricker F. et al., Nature Chemistry, vol. 14, (no. 8), pp. 942-948, 2022.

[2] Raucci U. et al., Journal of the American Chemical Society, vol. 144, (no. 42), pp. 19265-19271, 2022.

[3] Invernizzi M. et al., Journal of Chemical Theory and Computation, vol. 18, (no. 6), pp. 3988-3996, 2022.

[4] Ansari N. et al., Nature Communications, vol. 13, (no. 1), 2022.

[5] Grifoni E. et al., Nature Communications, vol. 12, (no. 1), 2021.

COMPUTATIONAL STATISTICS AND MACHINE LEARNING

Principal Investigator
Massimiliano Pontil
CHT@Erzelli

Description

Founded in 2016, Computational Statistics and Machine Learning studies the foundations of machine learning. We focus on statistically principled and computationally efficient approaches, using techniques from probability and statistics, and from numerical analysis and optimization. The latter offer a general framework for designing learning algorithms and analyzing their computational properties. The former provide the mathematical foundation for addressing data uncertainty and characterizing the generalization properties of learning algorithms. We have been active in different areas of machine learning theory and algorithms. Recent interests include algorithmic fairness, bandits and zero-order optimization, bilevel optimization, and learning dynamical systems.

Achievements

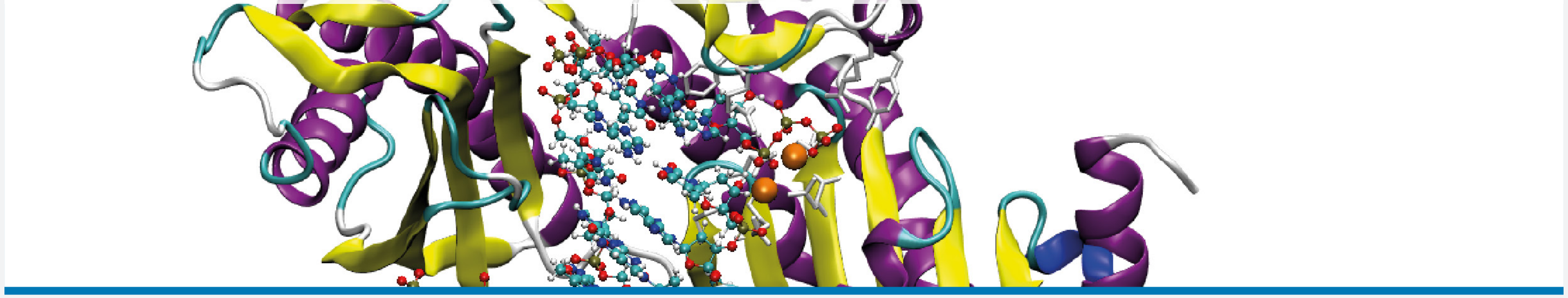
We have made significant contributions to machine learning theory and algorithms, including the areas of kernel methods, multitask and transfer learning, statistical learning theory and, more recently, algorithmic fairness, hyperparameter optimization, and metalearning.

We have a strong presence at the leading machine learning conferences (e.g. NeurIPS, ICML). Some of our former students are now researchers at leading research institutions and companies such as Google DeepMind, Microsoft, and Amazon AWS.

Representative Publications

[1] Kostic V. et al., Advances in Neural Information Processing Systems, vol. 35, 2022.
[2] Akhavan A. et al., Advances in Neural Information Processing Systems, vol. 2020-December, 2020.
[3] Chzhen E. et al., Advances in Neural Information Processing Systems, vol. 2020-December, 2020.
[4] Grazzi R. et al., 37th International Conference on Machine Learning, ICML 2020, vol. PartF168147-5, pp. 3706-3716, 2020.
[5] Denevi G. et al., 36th International Conference on Machine Learning, ICML 2019, vol. 2019-June, pp. 2814-2843, 2019.

COMPUTATIONAL MODELLING OF NANOSCALE AND BIOPHYSICAL SYSTEMS



Principal Investigator
Walter Rocchia
CHT@Erzelli

Description

Founded in 2014, the CONCEPT Lab's team of interdisciplinary scientists (from chemistry to engineering) work together to transform ideas and models into highly efficient computational implementations.

We seek to:

i. Develop new algorithms to accelerate the simulation of pharmaceutically relevant processes, e.g. interactions between proteins and drug candidates (JPC Lett, 2021). This includes the ambitious goal of protein design (NanoRes, 2021);
ii. Develop continuum electrostatics and advanced implicit solvent methods to improve how systems are described from the nanoscale to the mesoscale, focusing on constructing and analyzing molecular surfaces (Bioinf, 2019); and
iii. Exploit highly scalable machine-learning-enabled methods to predict biomolecular properties and to analyze large data produced by long MD simulations (ACS Cent Sci, 2017; JCTC, 2022).

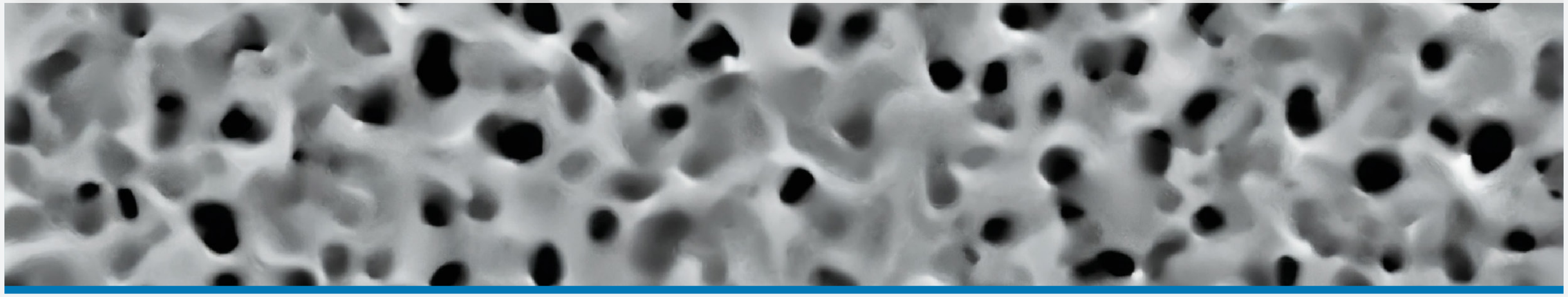
Achievements

In 2014, I cofounded BiKi Technologies, which provides solutions for drug design. In 2018, I received the Emerging Technologies in Computational Chemistry prize at the 256th ACS national meeting. In 2013, we developed NanoShaper, a cutting-edge software for building the molecular surface, which is becoming a standard in the community. Within the PROSEQO FET, in collaboration with the Plasmon Nanotechnology unit, I designed and simulated a biologically inspired nanopore for protein sequencing.

Representative Publications

[1] Reis P.B.P.S. et al., Journal of Chemical Theory and Computation, vol. 18, (no. 8), pp. 5068-5078, 2022.
[2] Spitaleri A. et al., Nano Research, vol. 14, (no. 1), pp. 328-333, 2021.
[3] Spitaleri A. et al., Journal of Physical Chemistry Letters, vol. 12, (no. 1), pp. 49-58, 2021.
[4] Decherchi S. et al., Bioinformatics, vol. 35, (no. 7), pp. 1241-1243, 2019.
[5] La Sala G. et al., ACS Central Science, vol. 3, (no. 9), pp. 949-960, 2017.

MULTISCALE AND QUANTUM SIMULATIONS



Principal Investigator
Sauro Succi
CLN_S@Sapienza

Description

We deal with three basic topics:

i. Computer simulation and machine learning (ML) methods for soft flowing matter, e.g. foams, emulsions, soft granular media, under strong confinement;
ii. High-performance multiscale methods for simulating fluid turbulence; and
iii. Quantum computing algorithms for classical physics.

The first two items are highly innovative extensions of the Lattice Boltzmann. Here, the IIT team is an international leader (as recognized by the ERC-AdG grant COPMAT). The simulations and ML software synergy have won us an ERC-PoC grant (DROPTRACK). The second item deals with the simulation of turbulent flows relevant to industrial devices, funded by the EuroHPC MULTIXSCALE grant. Thirdly, quantum computing explores a new challenging landscape in classical physics. It may encounter knowledge limits or fail to produce practical algorithms, but it holds intrinsic intellectual value.

Achievements

Our achievements include:

i. Developing cutting-edge computational methods for strongly confined dense emulsions and associated HPC codes for soft-flowing matter;
ii. Developing ML software for fast automatic droplet detection and tracking; and
iii. First quantum algorithm and circuit for fluid flows.

The first two topics have led to many discoveries, like new regimes of granular jetting and dripping modes, new non-equilibrium study states in hierarchical emulsions, and unexpected synergies between structural and fluid mechanics, which enable the survival of deep-sea sponges far down in the abyss.

Representative Publications

[1] Tiribocchi A. et al., Nature Communications, vol. 14, (no. 1), 2023.
[2] Durve M. et al., Physics of Fluids, vol. 34, (no. 8), 2022.
[3] Bogdan M. et al., Physical Review Letters, vol. 128, (no. 12), 2022.
[4] Falcucci G. et al., Nature, vol. 595, (no. 7868), pp. 537-541, 2021.

CULTURAL HERITAGE TECHNOLOGIES

Principal Investigator
Arianna Traviglia
CCHT@Ca'Foscari Venezia

Description

We seek to overcome the boundaries between disciplines in order to deliver innovative ways to care for cultural heritage. We do this by harnessing the disruptive potential of exponential technologies such as AI, digitalization, nanotechnologies, and robotics. We bring together humanities scholars, computer scientists, chemists, and material engineers to collaborate on interdisciplinary frontier projects. These projects combine consolidated approaches with the latest advances in technology and science. Together, we explore new ways to advance the analysis, safeguarding, and protection of cultural heritage.

We focus on:

i. Engineering advanced treatments to conserve cultural heritage;
ii. Expanding the accessibility of cultural heritage;
iii. Identifying, from space, heritage sites that merit protection;
iv. Facilitating the understanding, cataloguing, and reading of ancient documents; and
v. Stopping crimes against cultural heritage.

Achievements

Established in 2019, we have achieved international recognition and secured substantial competitive external funding (more than EUR 3 M for 11 applications) for projects in a traditionally underfunded research area. We currently coordinate a major HE project (RITHMS) to develop an AI-based platform to stop the trafficking of cultural heritage. We are also partners on nine projects funded by the EU and/or various space agencies. We are creating a new field of robotics dedicated to cultural heritage. We are revolutionizing the way that researchers develop new conservation treatments.

Representative Publications

[1] Davoudi H. et al., Neural Computing and Applications, 2023.
[2] Zanini R. et al., Journal of Analytical Atomic Spectrometry, 2023.
[3] Guidetti G. et al., Proceedings of the National Academy of Sciences of the United States of America, vol. 120, (no. 39), 2023.
[4] Sech G. et al., Digest - International Geoscience and Remote Sensing Symposium (IGARSS), 2023.
[5] Ljubenovic M. et al., Lecture Notes in Computer Science, vol. 13373 LNCS, pp. 152-161, 2022.

RD: LifeTech

Research Units

Principal Investigators

NEUROSCIENCE AND SOCIETY

Principal Investigator
Salvatore Maria Aglioti
CLN_S@Sapienza

Description

We seek to neurally represent the body image in healthy and brain-damaged patients, under the assumption that the body is at the core of many higher-order cognitive and social processes.

Our three research streams are:

i. Brain piezoing. In addition to standard noninvasive brain stimulation techniques (e.g. TMS, tES), we use focused ultrasound stimulation. This emerging technology can reach deep brain structures. We focus here on cognitive, social, and emotional control;
ii. Immersive virtual reality (IVR). We use the transformative power of IVR to clarify how and to what extent our body defines our psychology and behavior, and how these processes affect our interactions with others; and
iii. Deep body. We investigate the gastrointestinal system's role in modulating higher-order mental functions, including emotions and social decision making.

Achievements

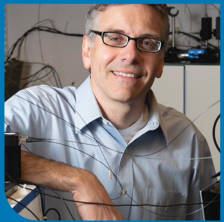
Our achievements include:

i. Brain piezoing. We developed ultrasound transducer configurations that stimulate deep brain structures without affecting superficial brain structures;
ii. IVR. We explored how the incorporation of positive (role) models can shape our attitudes towards legality, organized crime, and gender bias, ultimately countering antisocial behavior and promoting moral integrity; and
iii. Deep body. We are using the innovative technology of ingestibles, which transmit GPS gastrointestinal signals while complex mental tasks are being performed.

Representative Publications

[1] Scattolin M. et al., iScience, vol. 26, (no. 9), 2023.
[2] Frisanco A. et al., Scientific Reports, vol. 12, (no. 1), 2022.
[3] Monti A. et al., iScience, vol. 25, (no. 10), 2022.
[4] Villa R. et al., Neuroscience and Biobehavioral Reviews, vol. 142, 2022.
[5] Ponsi G. et al., npj Parkinson's Disease, vol. 7, (no. 1), 2021.

IIT@HARVARD



Principal Investigator

John Assad

IIT@HARVARD

Description

The IIT@Harvard Research Unit coordinates collaborative research between researchers at IIT and Harvard under a formal collaborative agreement. The projects have focused on: developing tools for systems neuroscience; developing devices in IIT engineering and applied physics labs; and validating and testing devices in the Department of Neurobiology labs at Harvard Medical School.

Previous joint projects have included: developing and testing advanced optical methods for site-specific optogenetic stimulation; developing and testing advanced high-density active silicon multielectrode probes; computational neuroscience approaches to optical imaging of cortical activity; and advanced noninvasive brain stimulation approaches to understanding normal brain function and rehabilitation of the damaged brain.

Achievements

The Research Unit has been extremely productive, especially given the negligible direct budget from IIT. Since 2014 alone, collaborative projects have produced dozens of papers in high-profile journals, including Nature (3), Nat Meth (2), Nat Neurosci (2), Neuron (2), and eLife (3). The collaborative projects have leveraged three five-year joint grants from the US National Institutes of Health, totaling USD 9.1 M, with more than USD 1.6 M in subcontracts for IIT labs. The Research Unit also led to the founding of the IIT spin-off companies Optogenix (Lecce) and Corticale (Genoa).

Representative Publications

[1] Spagnolo B. et al., Nature Materials, vol. 21, (no. 7), pp. 826-835, 2022.
[2] Conto F. et al., eLife, vol. 10, 2021.
[3] Hamilos A.E. et al., eLife, vol. 10, 2021.
[4] Pisano F. et al., Nature Methods, vol. 16, (no. 11), pp. 1185-1192, 2019.
[5] Pisanello F. et al., Neuron, vol. 82, (no. 6), pp. 1245-1254, 2014.

D3 PHARMACHEMISTRY

Principal Investigator
Tiziano Bandiera
CCT@Morego

Description

We work on two research areas.

Drug Discovery and Chemical Biology aims to discover novel small molecules with therapeutic application in specific diseases, and to use chemical biology approaches to investigate the mechanism of action of compounds in cells. We have identified compounds that recover the activity of F508del-CFTR, the most common mutant of the CFTR protein in cystic fibrosis patients. As part of the RNA Initiative, we are working to identify small molecule modulators of micro-RNA activity. This is a new way to regulate the intracellular levels of proteins involved in diseases.

The Nanoregulatory Platform, coordinated by Stefania Sabella, aims to expand our knowledge of the biotransformation of nanomaterials in the human body in order to highlight potential safety risks. The biotransformation of nanomaterials is mainly studied by using in vitro cellular systems that mimic human organ physiology.

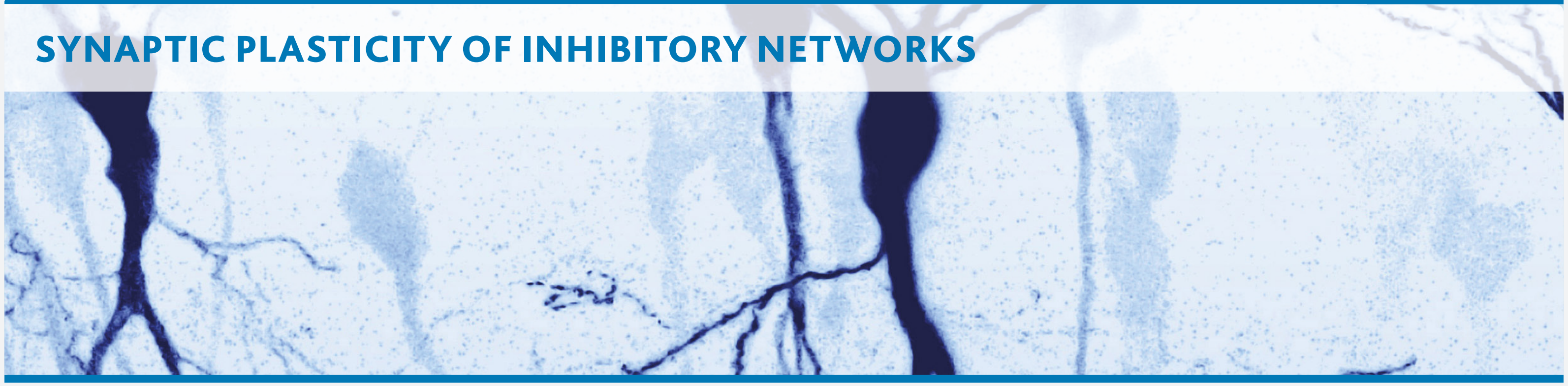
Achievements

In the last five years, we have filed seven patent applications, licensed a modulator of F508del-CFTR activity to a US-based biopharmaceutical company, and contributed to the preparation of a standard operating procedure on how to characterize nanomaterials for their potential toxicity based on their dissolution profile (in collaboration with BASF, Germany). Stefania Sabella was recently appointed an Expert in the Task Force of the working group on "Integrated in Vitro Approach for Intestinal Fate of Orally Ingested Nanomaterials" at Italy's Istituto Superiore di Sanità.

Representative Publications

[1] Genovese M. et al., PNAS Nexus, vol. 2, 2023.
[2] Di Cristo L. et al., Particle and Fibre Toxicology, 2022.
[3] Di Fruscia P. et al., Journal of Medicinal Chemistry, vol. 64, (no. 18), pp. 13327-13355, 2021.
[4] Pedemonte N. et al., Science advances, vol. 6, (no. 8), 2020.
[5] Di Cristo L. et al., Materials Today Bio, vol. 6, 2020.

SYNAPTIC PLASTICITY OF INHIBITORY NETWORKS



Principal Investigator
Andrea Barberis
CCT@Morego

Description

Synaptic Plasticity of Inhibitory Networks (SPIN) aims to understand how neuronal circuits are shaped by the coordinated plasticity of synaptic ensembles formed by excitatory and inhibitory inputs. The ultimate goal is to reveal the synaptic basis of network function and animal behavior.

The plasticity of excitatory and inhibitory synapses is an important source of neuronal and network flexibility, tuning neuronal excitability and reinforcing connectivity among neuron subgroups encoding specific memories.

We study the role of local synaptic plasticity crosstalk in shaping dendritic and network function in amygdala hippocampus circuits that process valence-related information. Our hypothesis is that "aversive" or "rewarding" sub-circuits exhibit distinct plasticity-induced spatial relationships, thereby implementing unique nonlinear dendritic activity.
in parallel, we focus on the nanoscale dynamics of synaptic proteins and the role of noncoding RNA in local protein synthesis.

Achievements

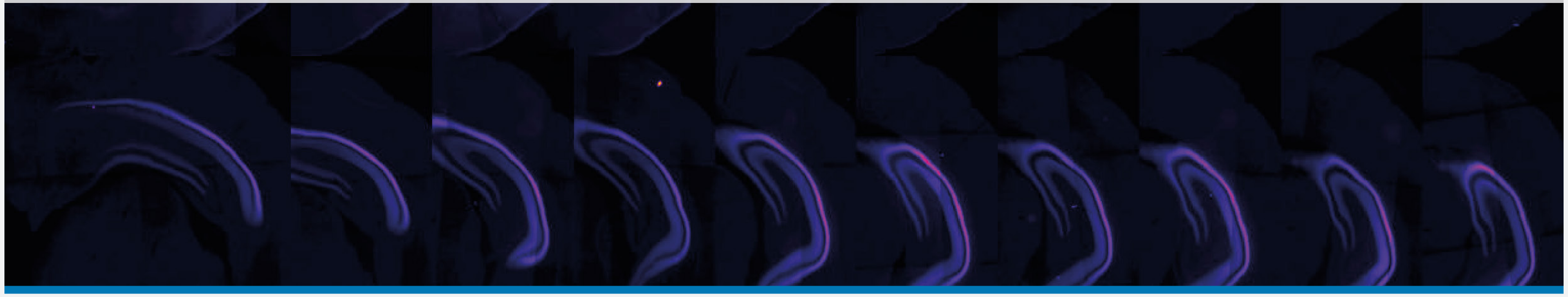
The SPIN lab, a pioneer in inhibitory synaptic plasticity research, has:

i. Clarified the role of GABAA receptor dynamics and synaptic nano-organization in long- and short-term plasticity of GABAergic synapses and demonstrated that the plasticity of GABAergic inhibitory synapses shares key similarities with that of excitatory glutamatergic synapses.
ii. Paved the way for a deeper understanding of the role of inhibition in neuronal networks by uncovering the local interplay between excitatory and inhibitory synapses as a novel mechanism influencing dendritic information processing and integration.

Representative Publications

[1] Ravasenga T. et al., Cell Reports, vol. 38, (no. 6), 2022.
[2] Polenghi A. et al., Cell Reports, vol. 31, (no. 10), 2020.
[3] Chiu C.Q. et al., Nature Reviews Neuroscience, vol. 20, (no. 5), pp. 272-281, 2019.
[4] de Luca E. et al., Neuron, vol. 95, (no. 1), pp. 63-69.e5, 2017.
[5] Petrini E.M. et al., Nature Communications, vol. 5, 2014.

NEUROSCIENCE AND SMART MATERIALS



Principal Investigator
Fabio Benfenati
NSYN@UniGe

Description

Our research is conducted in two interconnected fields:

i. Modelling neurological diseases for innovative and personalized therapeutic strategies acting at transcriptional and posttranscriptional levels; and
ii. Smart materials for intelligent neurointerfaces and neuroprosthetics.

We develop biosynthetic sensors/actuators and activity-dependent gene therapies to help neurons maintain the physiological homeostasis of neural networks in brain pathologies. We engineer active light-sensitive interfaces for neuronal stimulation, using organic electronics, photochromic molecules, and graphene. Advanced versions of injectable nanoparticle-based photoactive liquid prostheses are in preclinical studies. These technologies have quickly evolved from proof of principle to preclinical testing in pig models of degenerative blindness. We have launched the start-up NOVAVIDO with the goal of reaching clinical trials in humans.

Achievements

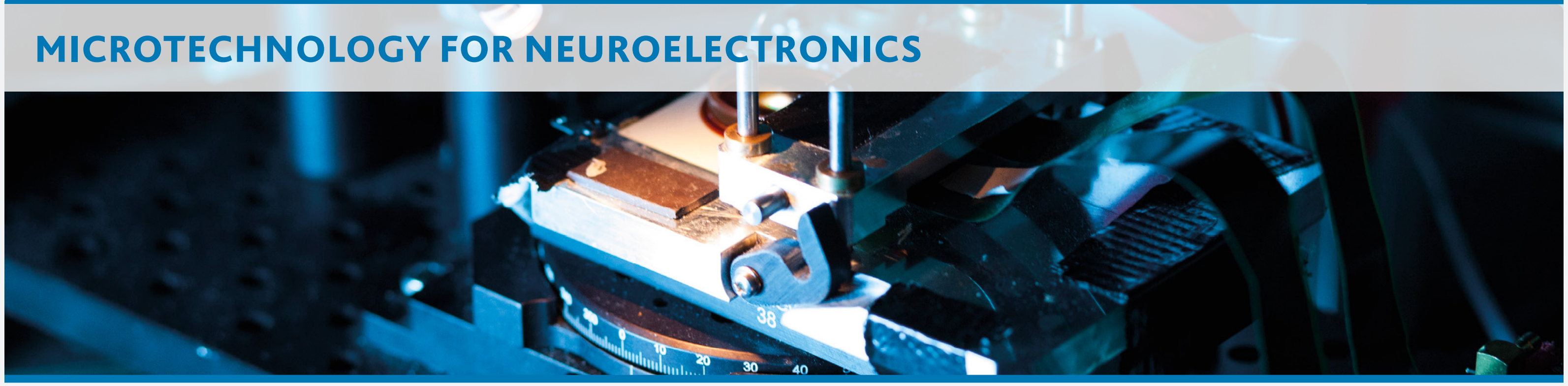
Our achievements include:

i. Chemo-optogenetic actuators for brain homeostasis. We engineer single-cell closed-loop sensor-actuator nanomachines that sense cell signals and boost neuronal homeostasis.
ii. Hybrid electrical and chemical synapses for wireless photostimulation. Polymeric nanoparticles and plasmonic nanochannels rescue vision in retinal dystrophies by forming light-activated synapses with target neurons.
iii. Azobenzene-based membrane nanomachines for neuronal photostimulation by modulating passive membrane properties.
iv. Bioengineering of the blood-brain barrier using tools to control its permeability on demand.

Representative Publications

[1] Francia S. et al., Nature Communications, vol. 13, (no. 1), 2022.
[2] Benfenati F. et al., Nature Reviews Materials, vol. 6, (no. 1), 2021.
[3] DiFrancesco M.L. et al., Nature Nanotechnology, vol. 15, (no. 4), pp. 296-306, 2020.
[4] Maya-Vetencourt J.F. et al., Nature Nanotechnology, vol. 15, (no. 8), pp. 698-708, 2020.
[5] Maya-Vetencourt J.F. et al., Nature Materials, vol. 16, (no. 6), pp. 681-689, 2017.

MICROTECHNOLOGY FOR NEUROELECTRONICS



Principal Investigator
Luca Berdondini
CCT@Morego

Description

We develop advanced neurotechnologies to bridge the gap between machines and the nervous system for neuroscience and clinical applications. Our key scientific and technological challenges are to overcome critical barriers in:

i. The miniaturization and tissue integration of neurodevices with advanced operational and computational performances, which are tailored to achieve a step-change in the spatiotemporal monitoring resolution of neural dynamics; and
ii. Identifying anomalous brain activity and delivering precise and spatially and temporally targeted interventional stimuli.

Our multidisciplinary approach to studying, building, and demonstrating advanced neuroelectronic systems therefore includes neuroscience, microtechnology, microelectronics, biophysics and computational science. This is applied to neuroscience research and to investigating therapeutic strategies and medical devices for brain diseases to impact healthcare.

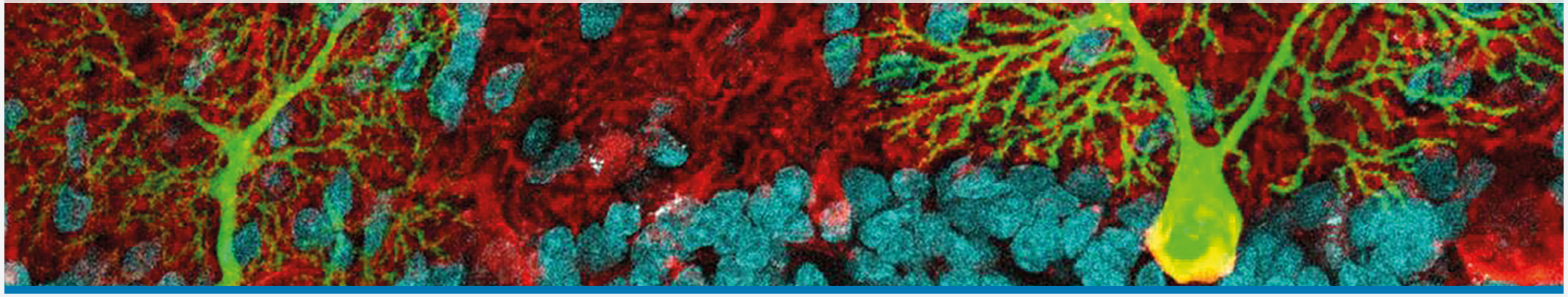
Achievements

The laboratory is a pioneer in CMOS microelectrode arrays. We have overcome critical barriers to integrating small-area front-end CMOS circuits that can fit underneath each micrometric electrode-pixel site. This enabled a spatiotemporal resolution suitable for monitoring neural activity. This was first demonstrated in vitro with planar electrode arrays. More recently, it enabled the IIT SiNAPS technology for implantable active dense CMOS-probes. Parallel to these scientific achievements, Berdondini co-founded 3Brain SA in 2011, and the lab resulted in Corticale Srl in 2021.

Representative Publications

[1] Riccitelli S. et al., Scientific Reports, vol. 12, (no. 1), 2022.
[2] Angotzi G.N. et al., Biosensors and Bioelectronics, vol. 126, pp. 355-364, 2019.
[3] Nieus T. et al., Scientific Reports, vol. 8, (no. 1), 2018.
[4] Barca-Mayo O. et al., Nature Communications, vol. 8, 2017.
[5] Hilgen G. et al., Cell Reports, vol. 18, (no. 10), pp. 2521-2532, 2017.

ORGANIC NEUROELECTRONICS



Principal Investigator
Fabio Biscarini
CTNSC@UniFe

Description

Established in 2019, our mission is to use organic electronic devices and soft materials to develop next-generation implantable devices for the multimodal recording and stimulation of the brain. Organic transistors form the basis of a platform for loco-regional treatments of various pathologies (e.g. epilepsy, Parkinson's disease, spinal cord injury) and for new tools to aid neurosurgery (e.g. tumor mapping of the brain cortex prior to surgery).

Our research activity is intertwined and coordinated with that of the Bidirectional Communication Research Unit led by Luciano Fadiga. We focus on translational applications on in vivo systems and human patients. Our emerging research directions include organic neuromorphic devices for on-board operations in implantable devices such as sensing, signal filtering, classification, and pattern recognition.

Achievements

We have developed devices and layouts for safe operations (no redox, no chemicals), biocompatibility, and minimal invasiveness.

In multimodal implantable devices, we have achieved:

i. Electrical recording of electrical signals from the cortex in animals and human patients with high signal-to-noise ratio and low power;
ii. Sensing dopamine in the rat brain with implanted neuromorphic devices; and
iii. The design and manufacture of ultraflexible array of transistors.

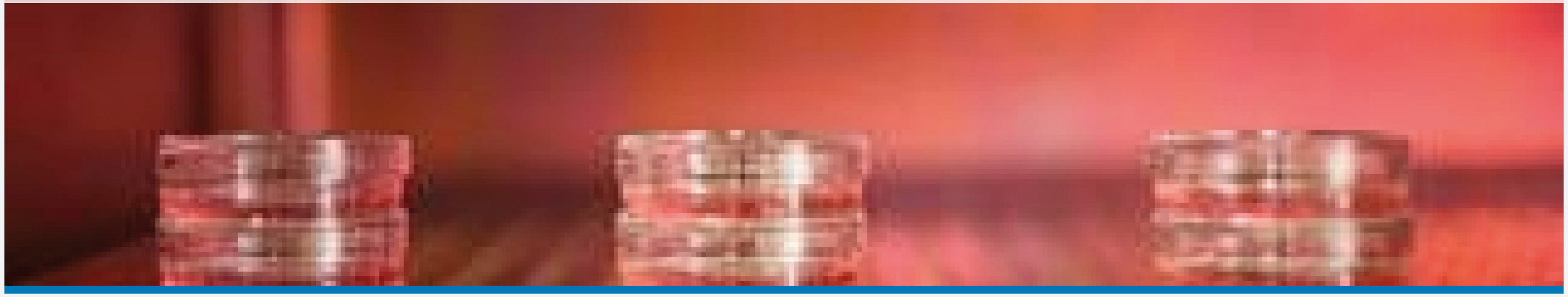
In organic neuromorphic devices, we have achieved:

i. A new sensing paradigm for catecholamines based on short-term plasticity of artificial synapses; and
ii. Signal filtering and classification with organic circuitry.

Representative Publications

[1] De Salvo A. et al., Advanced Materials Interfaces, 2023.
[2] Sensi M. et al., Advanced Materials, vol. 35, (no. 36), 2023.
[3] Di Lauro M. et al., Advanced Materials Interfaces, vol. 9, (no. 11), 2022.
[4] Lunghi A. et al., Advanced Materials Interfaces, vol. 9, (no. 25), 2022.
[5] Calandra Sebastianella G. et al., Advanced Electronic Materials, vol. 7, (no. 12), 2021.

NON CODING RNAS IN PHYSIOLOGY AND PATHOLOGY



Principal Investigator
Irene Bozzoni
CLN_S@Sapienza

Description

Mammalian transcriptomes largely comprise RNA molecules that do not encode for proteins (noncoding RNAs, ncRNAs), but rather control gene expression at many different levels. The specific mechanism of action of most ncRNAs has not yet been elucidated.

Due to their intrinsic scaffolding ability, these molecules have the dual function of tethering proteins as well as other nucleic acids. RNA-RNA and RNA-protein interactions allow the nucleation of different membraneless compartments, in which essential cellular processes occur, such as transcription, processing, translation, and intracellular transport.

We study the physiological role of neuronal ncRNAs, and seek to understand the pathogenic relevance of altered ncRNA metabolism in neurodegenerative processes. In particular, we want to assess how they affect neuron survival in different diseases, such as amyotrophic lateral sclerosis.

Achievements

Our PI has pioneered the discovery of several classes of ncRNAs, and contributed to discovering the function of many ncRNAs. She was the first to describe the miRNA sponging activity of lncRNA, a phenomenon that is largely consolidated in many different systems and ncRNA species. She established the use of antisense technology to treat diseases. She discovered circRNAs and identified their role in tumorigenesis. She was also the first to describe the ability of circRNA to be translated.

Representative Publications

[1] Carvelli A. et al., EMBO Journal, vol. 41, (no. 13), 2022.
[2] Nielsen A.F. et al., Nature Methods, vol. 19, (no. 10), pp. 1208-1220, 2022.
[3] Rossi F. et al., Molecular Cell, vol. 82, (no. 1), pp. 75-89.e9, 2022.
[4] Bozzoni I.Nature Reviews Genetics, 2021.
[5] Martone J. et al., EMBO Molecular Medicine, vol. 12, (no. 8), 2020.

3D CHROMATIN CONFORMATION AND RNA GENOMICS

Principal Investigator
Dafne Campigli Di Giammartino
CHT@Erzelli

Description

We seek to understand how noncoding RNAs (e.g. enhancer RNAs, long noncoding RNAs) and their epigenetic modifications regulate the 3D genome architecture and gene expression.

To this end, we use cutting-edge chromatin conformation assays, such as Hi-C and Hi-ChIP and other high-throughput sequencing techniques in combination with CRISPR-based genetic and epigenetic engineering tools in both mouse embryonic stem cells and human cancer stem cells.

By identifying the RNA-mediated organizational principles and vulnerabilities of 3D chromatin hubs, we aim to establish a novel conceptual framework which can be used to ultimately reprogram the regulatory logic of pluripotent cells, modulating their cell identity and tumorigenicity.

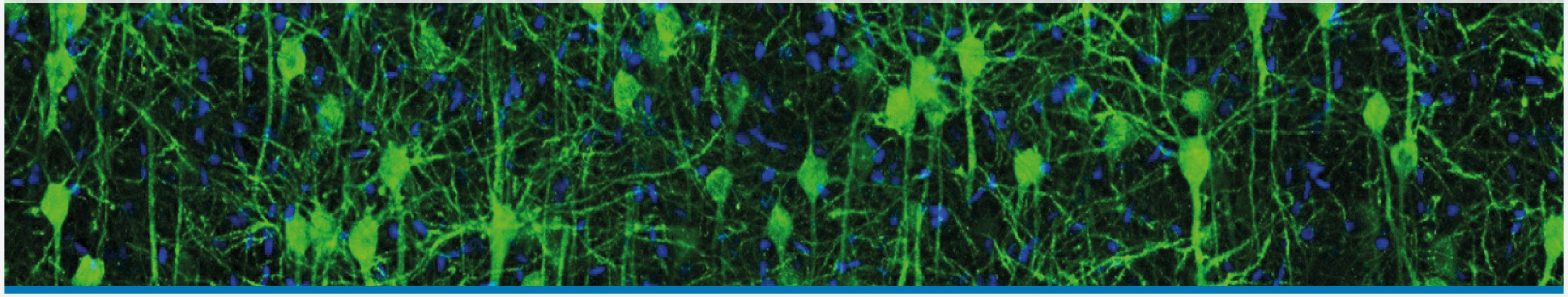
Achievements

Funding:
i. 2022-2027 Human Technopole Early Career Fellowship; and
ii. 2015-2018 New York Stem Cell Foundation fellowship.
Membership in societies:
i. FANTOM6 consortium;
ii. SIBBM- Società italiana di biofisica e biologia molecolare;
iii. ISSCR- International Society for Stem Cell Research; and
iv. RNA Society.
Invited seminars:
i. 2023 Human Technopole, Milan;
ii. 2023 INGM, Milan;
iii. 2023 4Dgenomics, Milan;
iv. 2021 Sapienza, Rome;
v. 2019 IFOM, Milan;
vi. 2019 EMBO: chromatin and epigenetics, Germany; and
vii. 2018 Keystone symposia: chromatin architecture, Canada.

Representative Publications

[1] Di Giammartino D.C. et al., Methods of Molecular Biology, 2022.
[2] Pelham-Webb B. et al., Molecular Cell, vol. 81, (no. 8), pp. 1732-1748.e8, 2021.
[3] Doane A.S. et al., Nature Immunology, vol. 22, (no. 10), pp. 1327-1340, 2021.
[4] Di Giammartino D.C. et al., Cell Cycle, vol. 19, (no. 19), pp. 2395-2410, 2020.
[5] Di Giammartino D.C. et al., Nature Cell Biology, vol. 21, (no. 10), pp. 1179-1190, 2019.

BRAIN DEVELOPMENT AND DISEASE



Principal Investigator
Laura Cancedda
CCT@Morego

Description

Brain development entails several biological processes that culminate in neuronal integration into a functional network of other developing cells. In particular, the extracellular milieu (cellular environment, CE) of a specific developing brain cell is characterized by the presence of other developing cells that may influence one another. Thus, what may be relevant for a specific developmental process at a given time in a particular brain area may not be significant at another time or place due to different CEs. The study of the diverse CEs during development may eventually lead to the discovery of specific therapeutic windows to address aberrant neurodevelopment, with reduced side effects.

Our three main Research Units for studying CE in rodents are:
i. Basic research on brain development;
ii. Translational research on new therapeutic approaches to neurodevelopmental disorders; and
iii. New technologies for obtaining clinically relevant animal models.

Achievements

Scientific production: ± 60 articles.

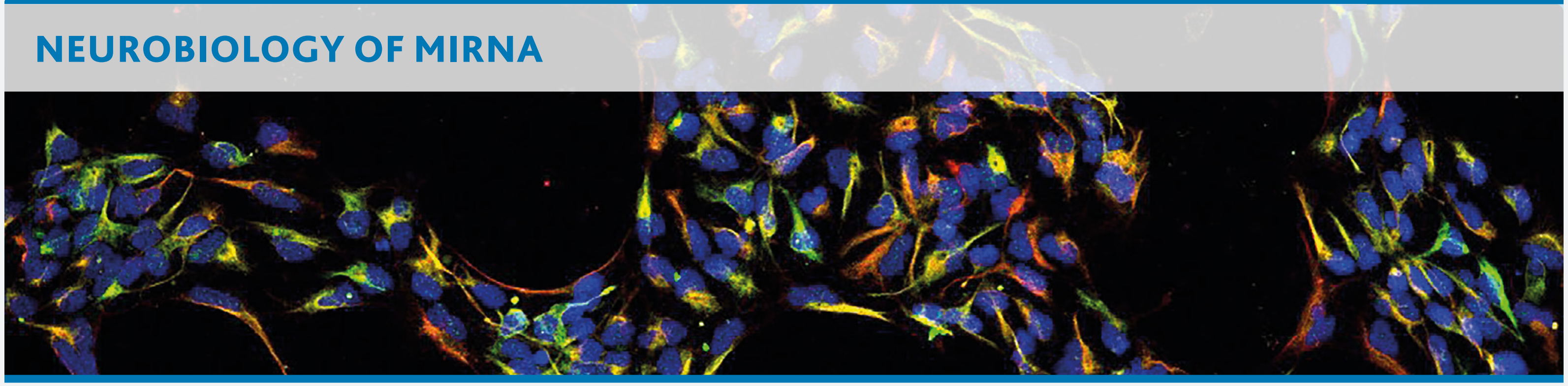
Funds: ± EUR 5 M total in time from international agencies (e.g. ERC), private companies, and patient associations.

Technology transfer activities (based on licensing of lab patents):
i. A clinical trial to repurpose a diuretic for cognitive impairment in down syndrome;
ii. A sponsored research agreement (> eur 1 m) with a us company for a gene therapy program;
iii. The launch of the iama therapeutics startup (eur 8 m) for new drugs for brain disorders with around eur 1.5 M devoted by iama to a research agreement with iit; and
iv. 1 Product (experimental tool) on the market with a japanese company.

Representative Publications

[1] Savardi A. et al., Chem, vol. 6, (no. 8), pp. 2073-2096, 2020.
[2] Pinto B. et al., Neuron, vol. 108, (no. 5), pp. 887-904.e12, 2020.
[3] Naskar S. et al., Nature Communications, vol. 10, (no. 1), 2019.
[4] Deidda G. et al., Nature Neuroscience, vol. 18, (no. 1), pp. 87-96, 2015.
[5] Deidda G. et al., Nature Medicine, vol. 21, (no. 4), pp. 318-326, 2015.

NEUROBIOLOGY OF MIRNA



Principal Investigator
Davide De Pietri Tonelli
CCT@Morego

Description

Our basic research dissects the roles of small noncoding RNAs (sncRNAs) in regulating neural stem cell (NSC) fate and neurogenesis. Our translational work uses sncRNAs to address brain pathologies arising from aberrant NSC fates.

Proper balance of NSC fate guarantees brain development, maintains lifelong neurogenesis, and prevents tumor formation. It is thus important to better understand and control NSC biology for therapeutic purposes. In addition to microRNAs, new classes of sncRNAs, including PIWI-interacting RNAs, were recently found in mammalian NSCs. This raises many fundamental questions and creates therapeutic opportunities.

A deeper knowledge of ncRNAs In neurogenesis is needed to mechanistically understand brain plasticity and develop the next generation of RNA-based therapies for brain diseases. This requires multidisciplinary expertise, so we collaborate with several IIT labs.

Achievements

Our lab has contributed to identifying essential regulatory functions of the miRNA pathway in the context of neurogenesis. We recently discovered that the piRNA pathway is required for proper neurogenesis in the adult hippocampus, underpinning its possible involvement in brain plasticity, neuroinflammation, and successful aging.

We are translating this knowledge into therapeutic applications for age-related brain diseases. Our projects have been cofunded by several national and international competitive grants, and have resulted in several patents and publications.

Representative Publications

[1] Gasperini C. et al., EMBO Reports, 2023.

[2] Pons-Espinal M. et al., Stem Cell Reports, vol. 12, (no. 6), pp. 1298-1312, 2019.

[3] Barca-Mayo O. et al., Nature Communications, vol. 8, 2017.

[4] De Pietri Tonelli D.Essentials of Noncoding RNA in Neuroscience: Ontogenetics, Plasticity of the Vertebrate Brain, pp. 1-316, Publisher: Elsevier Inc., 2017.

[5] Marinaro F. et al., EMBO Reports, vol. 18, (no. 4), pp. 603-618, 2017.

MULTISCALE BRAIN COMMUNICATION

Principal Investigator
Luciano Fadiga
CTNSC@UniFe

Description

The Center for Translational Neurophysiology of Speech and Communication is a center of excellence where research is continuously challenged by clinical and technological or applicative needs.

Our scientific goal is to study interactions and, in particular, to:

i. Understand the neural correlates of humans' ability to modulate vocal and bodily movements for communication (i.e. sensorimotor communication);
ii. Classify individual differences in this ability in health and disease; and;
iii. Investigate the possibility of realizing new technologically advanced interfaces with the brain.

Achievements

We are pioneers in recording from the cortex of awake human patients. We have developed new brain interfaces that use innovative electronics, and we have found new ways to improve their biocompatibility.

We have demonstrated the existence of motor resonant systems for action identification, even in phylogenetically low-level animals. We have found a new channel of communication during action imitation/learning (submovements). Additionally, we created a PhD School on Translational Neuroscience in conjunction with the University of Ferrara.

Representative Publications

[1] Carli S. et al., Chemistry - A European Journal, vol. 24, (no. 41), pp. 10300-10305, 2018.
[2] Soriano M. et al., Proceedings of the National Academy of Sciences of the United States of America, vol. 115, (no. 41), pp. 10452-10457, 2018.
[3] Carli S. et al., Sensors and Actuators, B: Chemical, vol. 271, pp. 280-288, 2018.
[4] Badino L. et al., Computer Speech and Language, vol. 36, pp. 173-195, 2016.

INTEGRATIVE NUCLEAR ARCHITECTURE

Principal Investigator
Irene Farabella
CHT@Erzelli

Description

Founded in Sep 2022, we integrate imaging techniques, genomics, structural bioinformatics, and theoretical physics to investigate the 3D genome organization plasticity in the single cell at an unprecedented level of detail. The 3D genome organization modulates various biological processes, including transcription, DNA replication, cell division, and meiosis. These processes are crucial for the differentiation and development of cells, and the onset of diseases.

Various molecular players (e.g. RNA) contribute to the 3D genome organization. We seek to understand the functional relationships between the components of the nucleus at various scales. We also seek to understand how these components influence gene regulation information plasticity in different physiological or pathological scenarios. We focus on 4D biological processes such as development and differentiation.

Achievements

We recently developed an innovative chromatin tracing technique, named sequential OligoSTORM, and a suite of innovative computational tools. These enable the direct visualization of multiple genomic loci in the nuclear space in their native context, offering new potential for multi-omics single-cell investigations.

We have also developed integrative modelling techniques for 3D genome reconstruction. We use these techniques to further characterize the relationship between genome structure and function, and to highlight the potential influence of noncoding RNAs on the 3D genome organization.

Representative Publications

[1] Harris H.L. et al., Nature Communications, vol. 14, (no. 1), 2023.
[2] Flores V. et al., Current Opinion in Cell Biology, vol. 82, 2023.

OPTICAL APPROACHES TO BRAIN FUNCTION

Principal Investigator
Tommaso Fellin
CCT@Morego

Description

When we see an object, hear a sound, or smell an odor, precise spatial and temporal patterns of electrical activity are generated within neuronal networks in specialized brain areas. This electrical representation of the external stimulus is believed to mediate our perception of the sensory experience.

However, there are still large knowledge gaps around the specific feature of evoked network dynamics that is used to drive behavior. We take a multidisciplinary approach to deciphering the computational principles of brain networks. We do this by developing innovative optical technologies for reading and artificially writing activity patterns in specialized ensembles of neurons with high spatial resolution in vivo.

Achievements

As principal investigator, Dr. Fellin has published 39 manuscripts and generated four patents. He has founded one start-up company and secured 19 external grants including one ERC-CoG, one EIC, several MSCAs, and continuous NIH BRAIN Initiative funding since 2014. He regularly serves as reviewer for the leading journals (including Nat Neurosci, Neuron, Nat Biotech, Nat Comm, Nat Mat, Nat Meth, Nat Prot, and Nat Rev Phys) and for various granting agencies (including EU FET, MSCA, ERC-StG, ERC-CoG, and ERC-AdG).

Representative Publications

[1] Kagiampaki Z. et al., Nature Methods, 2023.
[2] Sita L. et al., Nature Communications, vol. 13, (no. 1), 2022.
[3] Aime M. et al., Science, vol. 376, (no. 6594), pp. 724-730, 2022.
[4] Panzeri S. et al., Neuron, vol. 93, (no. 3), pp. 491-507, 2017.
[5] Beltramo R. et al., Nature Neuroscience, vol. 16, (no. 2), pp. 227-234, 2013.

UNIT FOR VISUALLY IMPAIRED PEOPLE

Principal Investigator
Monica Gori
CHT@Erzelli

Description

We study the development of multisensory integration and identify sensory impairments that impact the lives of children and adults with disabilities.

Our goal is to develop innovative solutions for early intervention in children. Specifically, we aim to:

i. Determine how multisensory integration develops during childhood at the behavioral and cortical levels;
ii. Investigate how the absence of one sensory modality impacts the development of other sensory signals;
iii. Identify technological solutions to enhance the child's abilities in rehabilitation, learning at school, and game development in order to improve quality of life and social inclusion;
iv. Test and validate our developed devices as responsible technologies with human-centered techniques by considering real-life and clinical settings; and
v. Understand the brain functions and develop neural models to implement sensory and cognitive functions in artificial systems.

Achievements

Comprising 35 members, our unit has published 180 papers since its creation in 2015 with an H-Index of 30, 3705 citations, and an average IF per journal of 3.7.

We have established important international collaborations and engaged in technology transfer including the creation of two Joint Labs with research hospitals. We have secured many European and Italian grants, serving as Coordinator for most of them.

Representative Publications

[1] Gori M. et al., Human Brain Mapping, vol. 44, (no. 2), pp. 656-667, 2023.
[2] Cuturi L.F. et al., Cyberpsychology, Behavior, and Social Networking, 2023.
[3] Gori M. et al., Current Biology, vol. 31, (no. 22), pp. 5093-5101.e5, 2021.
[4] Gori M. et al., Neuroscience and Biobehavioral Reviews, vol. 109, pp. 54-62, 2020.
[5] Cappagli G. et al., Scientific Reports, vol. 9, (no. 1), 2019.

FUNCTIONAL NEUROIMAGING

Principal Investigator
Alessandro Gozzi
CNCS@UniTn

Description

We study the functional organization of the mammalian brain at the macroscale. We are interested in mapping and decoding network-scale patterns of spontaneous brain activity across species.

A major goal is to unravel the neurophysiological basis of brain-wide functional connectivity as measured with fMRI, and the underpinnings of its disruption in developmental disorders like autism. As part of ERC-funded research, we have therefore developed a novel research platform to map and perturb the functional connectome in the awake mouse brain. Using this approach, we can now establish causal relationships between macroscale network activity (as assessed with fMRI) and its genetic, neurophysiological, and pathological determinants. Our work is revealing a set of fundamental rules linking regional patterns of brain activity to macroscale brain network dynamics, and the significance of its disruption in brain disorders.

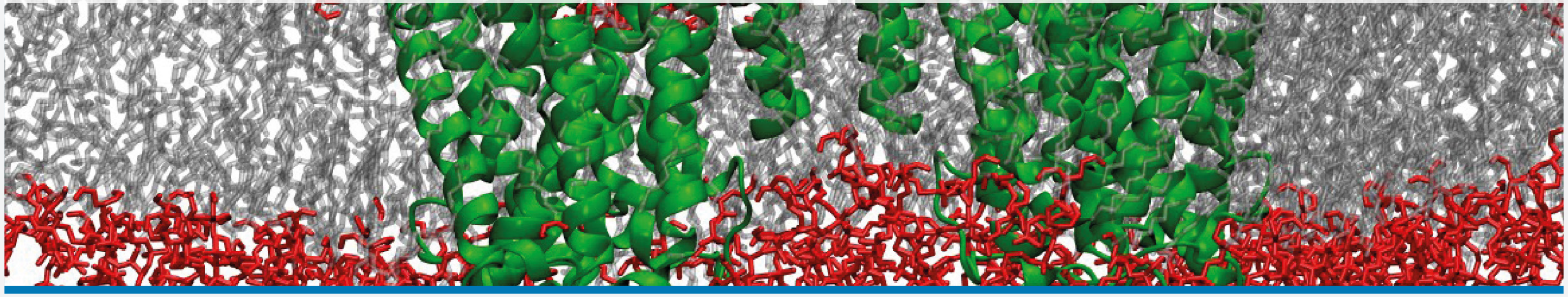
Achievements

Recent awards and grants include: Simmons Foundation (SFARI) Human Cognitive and Behavioral Neuroscience Award (2023); Stanford MCHRI Neuropsychiatry Research Awards (2023); ERC Starting grant (2018); Brain and Behavior Foundation, NARSAD Independent Investigator Grant (2017); Simmons Foundation (SFARI) Pilot Investigator Award (2016); and Simmons Foundation (SFARI) Explorer Award (2014).

Representative Publications

[1] Rocchi F. et al., Nature Communications, vol. 13, (no. 1), 2022.
[2] Gutierrez-Barragan D. et al., Current Biology, vol. 32, (no. 3), pp. 631-644.e6, 2022.
[3] Pagani M. et al., Nature Communications, vol. 12, (no. 1), 2021.
[4] Coletta L. et al., Science advances, vol. 6, (no. 51), 2020.
[5] Gutierrez-Barragan D. et al., Current Biology, vol. 29, (no. 14), pp. 2295-2306.e5, 2019.

MOLECULAR MEDICINE



Principal Investigator
Benedetto Grimaldi
CCT@Morego

Description

We conduct multidisciplinary studies that integrate findings from diverse fields to identify and validate novel therapeutic strategies based on targeting multiple molecular pathways (e.g. autophagy, the circadian clock). In addition, our studies aim to introduce novel relevant molecular tools for assessing both the efficacy and potential toxicity of diverse therapeutic agents under clinically relevant conditions.

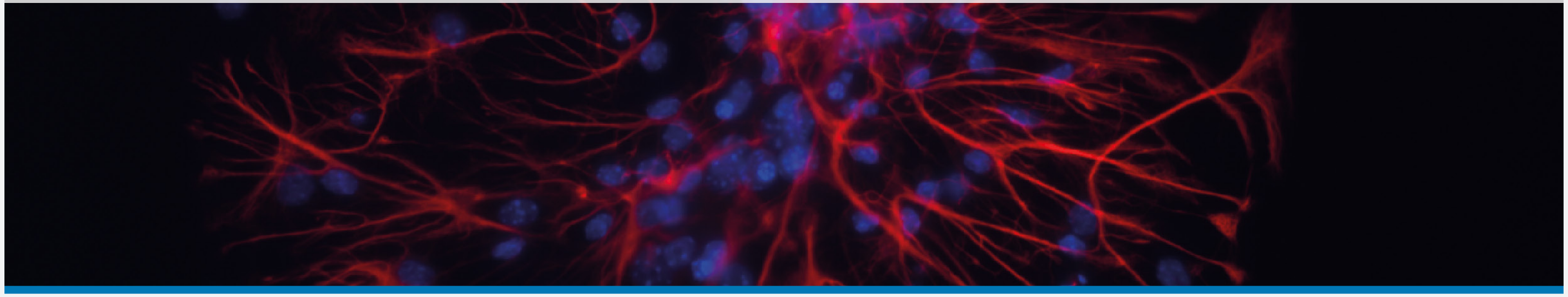
Achievements

Our drug discovery programs have identified innovative multitarget agents to treat diverse human pathologies, such as cancer, bacterial infection, and metabolic diseases. For example, we disclosed the first class of novel anticancer agents acting on both circadian and autophagy processes. We are also developing novel nutraceuticals and RNA-based technologies to treat age-related diseases.

Representative Publications

[1] Qin Y. et al., Cancer Letters, vol. 570, 2023.
[2] Palomba M. et al., Journal of Medicinal Chemistry, 2023.
[3] Duca M. et al., Nature Reviews Chemistry, 2022.
[4] Blazevits O. et al., International Journal of Molecular Sciences, vol. 21, (no. 7), 2020.
[5] Allavena G. et al., Cell Death and Disease, vol. 9, (no. 7), 2018.

NON-CODING RNAS AND RNA-BASED THERAPEUTICS



Principal Investigator
Stefano Gustincich
CHT@Erzelli

Description

We aim to understand the function of RNA as output of the noncoding portion of the genome in brain development and physiology, and in neurodevelopmental and neurodegenerative diseases.

Some years ago we discovered the SINEUPs, a functional class of antisense long noncoding RNAs (lncRNAs) that increase translation of their sense gene. We are studying the details of SINEUPs' mechanism, how many regulatory RNAs present a SINEUP-like activity, and their biological functions. We are optimizing the SINEUP technology as a new platform of RNA therapeutics. We are showing that transposable elements of the L1 type play a crucial role in brain development, behavior, and diseases, acting as regulatory lncRNAs and independently from retrotransposition. We are investigating the impact of these noncoding sequences on human diseases by sequencing the whole genome of large cohorts of individuals at the Center for Personalized, Preventive and Predictive Medicine at Aosta.

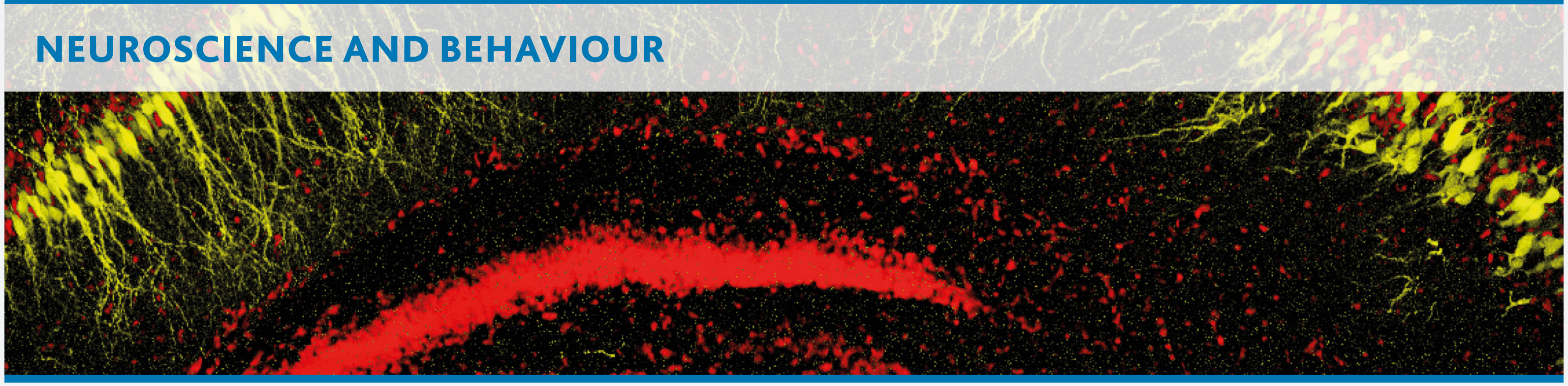
Achievements

i. We have shown that L1 elements act as long noncoding RNAs to regulate corticogenesis. They are upregulated in a selected group of individuals with autism spectrum disorder.
ii. We have validated SINEUP technology in preclinical models of diseases with special emphasis on genetic haploinsufficiencies and on Parkinson's disease.
iii. We have significantly advanced our understanding of SINEUP's mechanism of action, showing it is based on an internal ribosomal entry site activity and a chemical RNA modification.

Representative Publications

[1] D'Agostino S. et al., bioRxiv, 2023.
[2] Mangoni D. et al., Nature Communications, vol. 14, pp. 4974, 2023.
[3] Pierattini B. et al., Molecular Therapy - Nucleic Acids, vol. 32, pp. 402-414, 2023.
[4] Espinoza S. et al., Molecular Therapy, vol. 28, (no. 2), pp. 642-652, 2020.
[5] Bon C. et al., Nucleic Acids Research, 2019.

NEUROSCIENCE AND BEHAVIOUR



Principal Investigator
Giandomenico Iannetti
CLN_S@Sapienza

Description

The research group led by Prof Giandomenico Iannetti, uses psychophysics and neurophysiology to address fundamental questions about how animals cope with a changing world through perception and action, - specifically how the nervous system detects and reacts to surprising environmental events. These events elicit large and widespread brain responses that rapidly change the state of the cerebral cortex and facilitate appropriate behaviors. This research activity is relevant for studying pain, defensive behaviors, action selection, and peripersonal space.

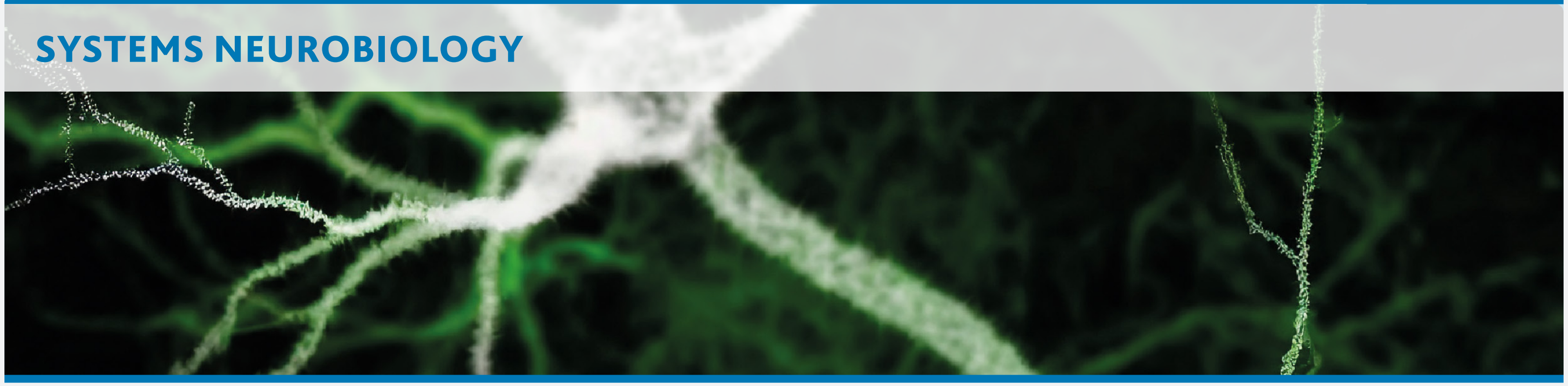
Achievements

i. We provided a radical new view on cortical pain processing. This transformed how researchers investigate mechanisms of pain and interpret functional brain imaging results.
ii. We transformed current thinking about the extent to which defensive reflex responses are stereotypical.
iii. We solved the long- standing debate about the significance of peripersonal space, which is better understood as mapping onto behavior rather than stimulus proximity.
iv. Many former lab members are now in tenured academic positions worldwide, securing prestigious funding (e.g. ERC, MRC, Wellcome Trust).

Representative Publications

[1] Salomons T.V. et al., Nature Neuroscience, vol. 25, (no. 11), pp. 1396-1398, 2022.
[2] Guo Y. et al., PLoS Biology, vol. 18, (no. 4), 2020.
[3] Hu L. et al., Proceedings of the National Academy of Sciences of the United States of America, vol. 116, (no. 5), pp. 1782-1791, 2019.
[4] Bufacchi R.J. et al., Trends in Cognitive Sciences, vol. 22, (no. 12), pp. 1076-1090, 2018.
[5] Jin Q.Q. et al., Journal of Neuroscience, vol. 38, (no. 24), pp. 5538-5550, 2018.

SYSTEMS NEUROBIOLOGY



Principal Investigator
Giuliano Iurilli
CNCS@UniTn

Description

Our goal is to understand the fundamental principles behind the function and organization of neural circuits involved in estimating a model of an animal's external and internal environment.

Many basic functions of our brain, from motor control to more cognitive operations such as foraging, require us to decipher what is outside the brain using sensory information from exteroceptors and interoceptors. We investigate which circuits are involved in this representation and which computations these circuits perform. In addition, we aim to identify the activity dynamics and mechanisms by which these computations are generated.

Our strategy focuses on how the neural activity dynamics in the mouse brain integrate olfactory and visuo-tactile information to build an internal model of their surrounding space, and how internal states such as hunger, thirst, or social isolation shape this model in order to funnel the neural activity towards the most appropriate behavior.

Achievements

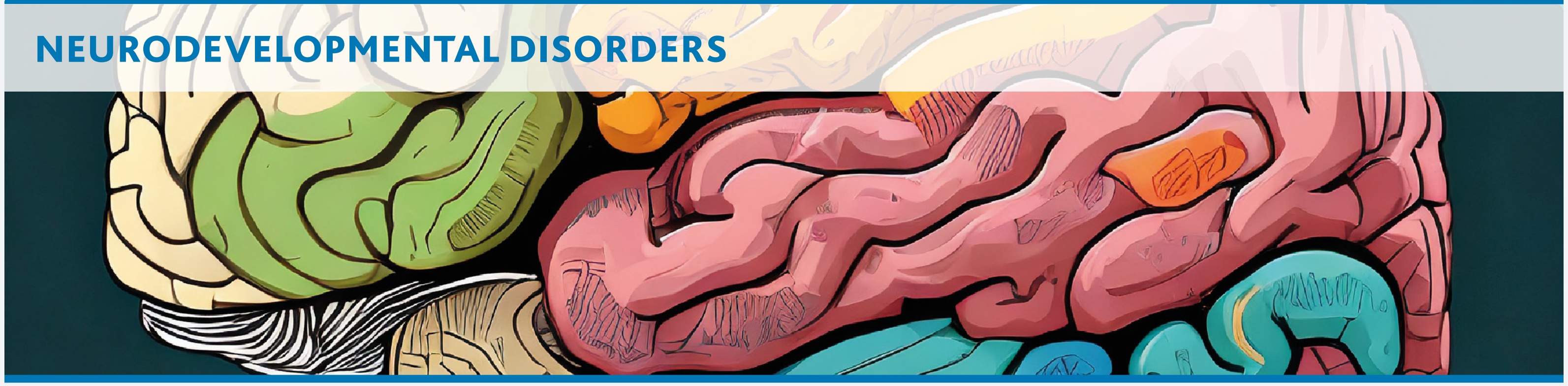
We have:

i. Established state-of-the-art high-density optical and electrophysiological tools to record and reversibly perturb neural activity in behaving mice.
ii. Developed machine-vision and machine-learning techniques to quantify different aspects of the mouse's foraging behavior.
iii. Developed several methods for modeling functional neural networks. In our first 2 years, we identified a novel computational principle deployed by the olfactory system (and likely other sensory systems) to distinguish self-generated and externally generated sensory stimuli without using the canonical motor corollary discharges.

Representative Publications

[1] Dehaqani A. et al., bioarXiv, 2023.
[2] Pashkovski S.L. et al., Nature, vol. 583, (no. 7815), pp. 253-258, 2020.
[3] Iurilli G. et al., Neuron, vol. 93, (no. 5), pp. 1180-1197, 2017.
[4] Olcese U. et al., Neuron, vol. 79, (no. 3), pp. 579-593, 2013.
[5] Iurilli G. et al., Neuron, vol. 73, (no. 4), pp. 814-828, 2012.

NEURODEVELOPMENTAL DISORDERS



Principal Investigator
Michael Vincent Lombardo
CNCS@UniTn

Description

Autism and other related neurodevelopment disorders are heterogeneous at every scale, from genome to phenome. However, the diagnostic label does not reflect this heterogeneity. We seek to better understand how and why heterogeneity manifests in individuals with neurodevelopmental disorders, such as autism. Our study of heterogeneity in autism cuts across scales, including genomics, neuroscience, cognition, and behavior. Our goal is to identify ways to better explain differential biology, outcomes, and responses to treatment in individuals with autism and other neurodevelopmental disorders.

Achievements

Our achievements include:

i. Isolating the subtypes of early language outcomes in biologically highly differentiated autism;
ii. Identifying heterogeneous excitation-inhibition imbalance mechanisms in autism;
iii. Discovering the early genomic predictors behind differential responses to early intervention treatment in autism;
iv. Demonstrating that autism manifests differently in males and females at the behavioral, neural, and genomic levels; and
v. Demonstrating that prenatal steroidogenic and maternal immune factors influence autism risk.

Representative Publications

[1] Mandelli V. et al., Nature Mental Health, 2023.
[2] Xiao Y. et al., Nature Human Behaviour, vol. 6, (no. 3), pp. 443-454, 2022.
[3] Lombardo M.V. et al., Science advances, vol. 7, (no. 36), 2021.
[4] Lombardo M.V. et al., Molecular Psychiatry, vol. 26, (no. 12), pp. 7641-7651, 2021.
[5] Lombardo M.V. et al., eLife, vol. 8, 2019.

BIO-LOGIC MATERIALS

Principal Investigator
Paolo Netti
CABHC@CRIB

Description

We aim to decipher and master the crosstalk between cells and their microenvironment in order to achieve full epigenetic cell regulatory control. These studies are fundamental to designing the next generation of cell-instructive materials and regenerating native human tissue in vitro.

The long-term goal is to program cellular microenvironments by encrypting the highly controlled time-space presentation of morphophysical signals to repair, reconstitute, and interrogate native tissues in vivo and in vitro. Our lab's unique aspect is the ability to optimize functional properties with high spatial resolution, creating materials that can control interactions with the biological surroundings at nanoscale. Responding to changes in the biological environment, smart interfaces can control and guide specific molecular or cellular events, such as morphogenesis, tissue remodeling, and cell repair.

Achievements

Our group has elucidated the basic mechanisms by which biochemical and morphophysical patterning regulates and controls cells and tissue functions. Our nanoengineered surfaces can effectively regulating cells' epigenetic states.

We have also used proprietary technology to build a library of 3D histologically and functionally competent human tissues, including of the intestine, lung, liver, uterine cervix, heart, blood-brain barrier, epithelium, and connective tumors. These tissues have been integrated into microfluidics systems to obtain reliable tissue-on- chip devices.

Representative Publications

[1] Imparato G. et al., Lab on a Chip - Miniaturisation for Chemistry and Biology, vol. 23, (no. 1), pp. 25-43, 2022.

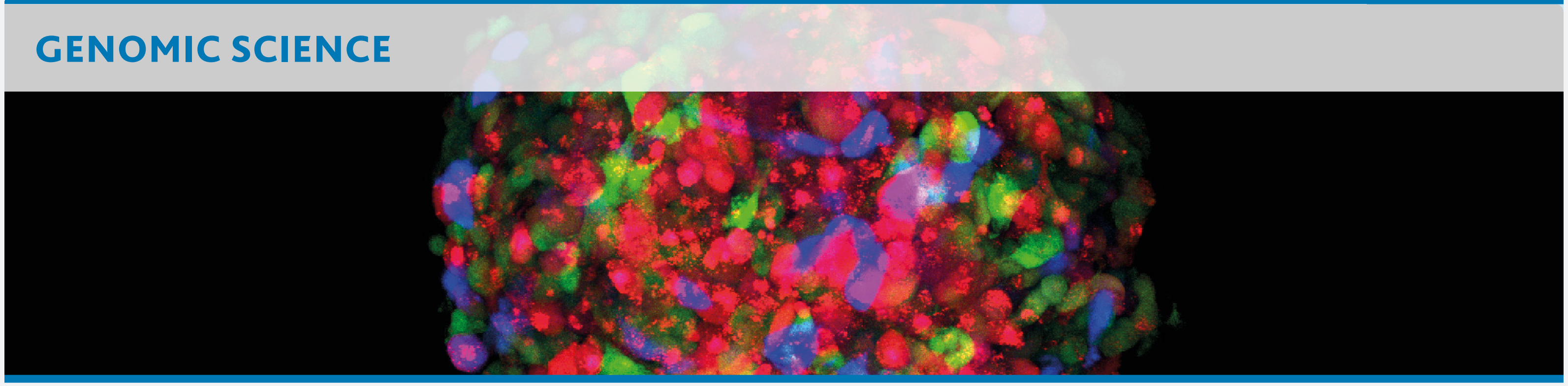
[2] De Martino S. et al., Advanced healthcare materials, 2020.

[3] Panzetta V. et al., Proceedings of the National Academy of Sciences of the United States of America, vol. 116, (no. 44), pp. 22004-22013, 2019.

[4] Iaccarino G. et al., Acta Biomaterialia, vol. 89, pp. 265-278, 2019.

[5] Mazio C. et al., Biomaterials, vol. 192, pp. 159-170, 2019.

GENOMIC SCIENCE



Principal Investigator
Francesco Nicassio
CGS@SEMM

Description

My scientific goal is to elucidate the regulatory mechanisms involving noncoding RNAs and gene expression control at the transcriptional, posttranscriptional, and epigenetic levels. These key insights can help identify disease markers or potential targets for pharmacological intervention.

We achieve this with advanced genomics technologies, including:

i. Nanopore sequencing, which is a single-molecule sequencing platform for the multimodal analysis of transcripts, mapping isoforms, RNA processing events, and the study of RNA modifications;
ii. Single-cell multi-omics, which combine transcriptional and epigenetic analyses at single-cell resolution in order to deconvolve cellular and molecular heterogeneity and characterize gene-regulatory networks within subpopulations; and
iii. A CRISPR-based platform for genetic screening in order to identify molecular targets that are effective in cancer phenotypes, including growth, drug tolerance, and metastasis.

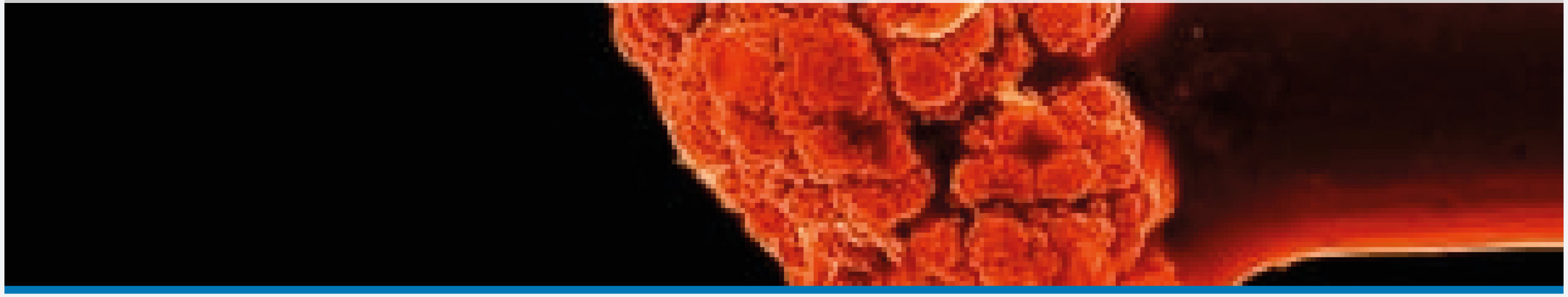
Achievements

i. In the area of gene expression control via microRNA mechanisms, we revealed the dynamics of microRNA decay. We also highlighted a novel mechanism, target-directed miRNA degradation, which is involved in cell behavior and human cancer.
ii. Plasticity is a key mechanism in cancer biology, fueling heterogeneity and cancer stem cells (CSC). We have contributed to characterizing the transcriptional and epigenetic mechanisms that sustain CSC identity in breast cancer, highlighting the role of key noncoding RNAs in cancer plasticity.

Representative Publications

[1] Ugolini C. et al., Nucleic Acids Research, vol. 50, (no. 6), pp. 3475-3489, 2022.
[2] Simeone I. et al., Nucleic Acids Research, vol. 50, (no. 4), pp. 2019-2035, 2022.
[3] Tordonato C. et al., Journal of Cell Biology, vol. 220, (no. 5), 2021.
[4] Ghini F. et al., Nature Communications, vol. 9, (no. 1), 2018.
[5] Marzi M.J. et al., Genome Research, vol. 26, (no. 4), pp. 554-565, 2016.

NEUROSCIENCE OF PERCEPTION AND ACTION



Principal Investigator
Giacomo Novembre
CLN_S@Sapienza

Description

Who? We are a group of brain and behavioral scientists, with diverse cultural and educational backgrounds, combining natural and social sciences.

What? We investigate fundamental questions about how humans perceive and act in the world. We are currently investigating two widespread human capacities: social interaction and musicality (the biological predispositions that make humans universally suited to musical behavior). We study these capacities in human adults, and compare them to human infants or nonhuman primates.

How? Our research integrates traditional (i.e. laboratory-based) and naturalistic approaches to human brain and behavior, including free behavior and ecologically valid sensory stimulation. We believe in the synergy of these approaches: naturalistic settings offer the opportunity to observe phenomena in their authentic context, while laboratory-based research is essential for rigorously testing new theories.

Achievements

Established in 2021, we are working on 3 EU-funded projects (1 ERC StG and 2 MSCA-IF).

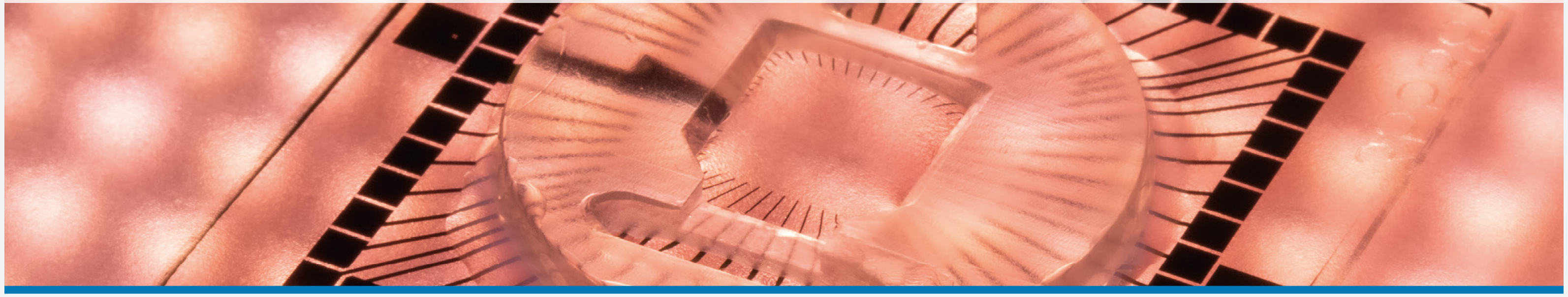
Our current topics include:
i. Neural bases of musicality in human adults and infants and in macaques
ii. Collective dance and music making and
iii. Spontaneous social interaction (both verbal and nonverbal).

Our current methodologies include neuroimaging (electroencephalography); brain stimulation (transcranial electric stimulation); physiology of the heart, pupil, skin, respiration; motion tracking (full-body optical or video-based motion capture, eye tracking); acoustic analysis; and computational modelling (machine learning).

Representative Publications

[1] Nguyen T. et al., Developmental Cognitive Neuroscience, vol. 63, 2023.
[2] Koul A. et al., iScience, vol. 26, (no. 3), 2023.
[3] Bianco R. et al., Current Biology, 2023.
[4] Keller P.E. et al., Biology Letters, vol. 19, 2023.
[5] Koul A. et al., NeuroImage, vol. 277, 2023.

ENHANCED REGENERATIVE MEDICINE



Principal Investigator
Gabriella Panuccio
CCT@Morego

Description

We focus on brain regeneration and functional repair via biohybrid systems. These systems are based on the symbiotic interaction between biological brain tissue replicas (grafts) and implantable adaptive neuroprostheses (artificial counterpart) that guide the anatomical and functional integration into the diseased brain.

Along with developing functional brain tissue replicas, we also conceptualize and test the proof of concept of potential new neuroprostheses and implantable biohybrid devices for brain modulation and regeneration. The device design results from collaborative efforts with the Electronic Design Laboratory and with a pool of international experts in brain implantable devices.

We routinely use microelectrode array electrophysiology in vitro (brain slices and cell cultures). Our current focus is mesial temporal lobe epilepsy, with the goal of scaling our results to the in vivo setting and expanding them to other brain disorders, such as stroke.

Achievements

We have obtained a hippocampal interictal-based grammar for AI-driven DBS in limbic epilepsy.

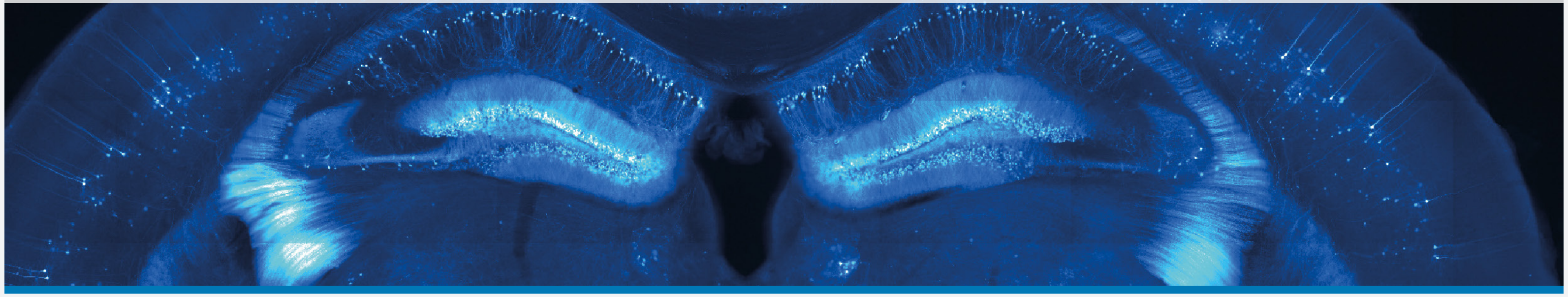
We have demonstrated the restoration of the hippocampal loop functional connectivity and control of its ictogenicity via interictal-driven stimulation for a bridging neuroprosthesis.

Building on these results, we have conceptualized a biohybrid device, which encapsulates stem cell-derived hippocampal cells for neuromodulation in limbic epilepsy. Here, alginate scaffolds promote the formation and physiological functionality of hippocampal networks, which otherwise exhibit spontaneous epileptogenesis.

Representative Publications

[1] Caron D. et al., Journal of Neural Engineering, vol. 20, (no. 4), 2023.
[2] Ronchini M. et al., Journal of Neural Engineering, 2023.
[3] Christensen D.V. et al., Neuromorphic Computing and Engineering, vol. 2, (no. 2), 2022.
[4] Caron D. et al., Biology, vol. 11, (no. 3), 2022.
[5] Ciarpella F. et al., iScience, vol. 24, (no. 12), 2021.

GENETICS OF COGNITION



Principal Investigator
Francesco Papaleo
CCT@Morego

Description

We are social creatures. Complex and continuous social interactions are evolutionary conserved processes, shaping all animals' life and survival. Social behaviors define each individual's wellbeing and the entire society. Deficits in socio-cognitive abilities have critical impact on the affected individuals and their relatives, on public health, and on long-term life outcomes. This is most evident in psychiatric and neurodevelopmental disorders (e.g. schizophrenia, autism).

Our vision is to uncover the mechanisms behind sociocognitive (dis) abilities by using a bidirectional mouse-human approach. We focus on distinct components of sociocognitive processes, from social perception (emotion recognition) to social decision (altruistic/selfish choices). Combining our innovative behavioral paradigms with cutting-edge in vivo techniques, we seek to understand the genetics, cell-specific, and circuit-specific mechanisms of distinct sociocognitive processes.

Achievements

We have:

i. Demonstrated that appropriately designed paradigms for mice can provide meaningful insights into sociocognitive processes in humans (and into psychiatric and neurodevelopmental disorders).
ii. Discovered that somatostatin inhibitory neurons in the prefrontal cortex (PFC) are essential for emotion discrimination, and that enhancing oxytocin signaling in the central amygdala can restore deficits in recognizing emotions.
iii. Demonstrated how preference for altruistic or selfish choices is modulated by familiarity, sex, social contact, hunger, hierarchy, emotional state matching, and a basolateral amygdala-PFC circuit.

Representative Publications

[1] Mastrogiacomo R. et al., Molecular Psychiatry, vol. 27, (no. 10), pp. 4201-4217, 2022.
[2] Scheggia D. et al., Nature Neuroscience, vol. 25, (no. 11), pp. 1505-1518, 2022.
[3] Scheggia D. et al., Nature Neuroscience, vol. 23, (no. 1), pp. 47-60, 2020.
[4] Ferretti V. et al., Current Biology, vol. 29, (no. 12), pp. 1938-1953.e6, 2019.
[5] Scheggia D. et al., Nature Communications, vol. 9, (no. 1), 2018.

FUNCTIONAL ARCHITECTURE OF NEURAL CIRCUITS

Principal Investigator
Federico Rossi
CNCS@UniTn

Description

The Rossi lab investigates the functional architecture behind the connectivity between neurons in the brain. We seek to map the circuit logic that orchestrates sensory and motor computations, and to understand how its dysfunction underlies neurological disorders. We are therefore developing methods to bridge the gap between function, connectivity, and gene expression in neural circuits in vivo. These methods include two-photon imaging, viral tracing, optogenetics, and transcriptomics. We aim to flexibly apply our methodological advances throughout the brain in order to discover the general principles that govern the assembly, function, and plasticity of neural circuits, and to understand how they drive behavior.

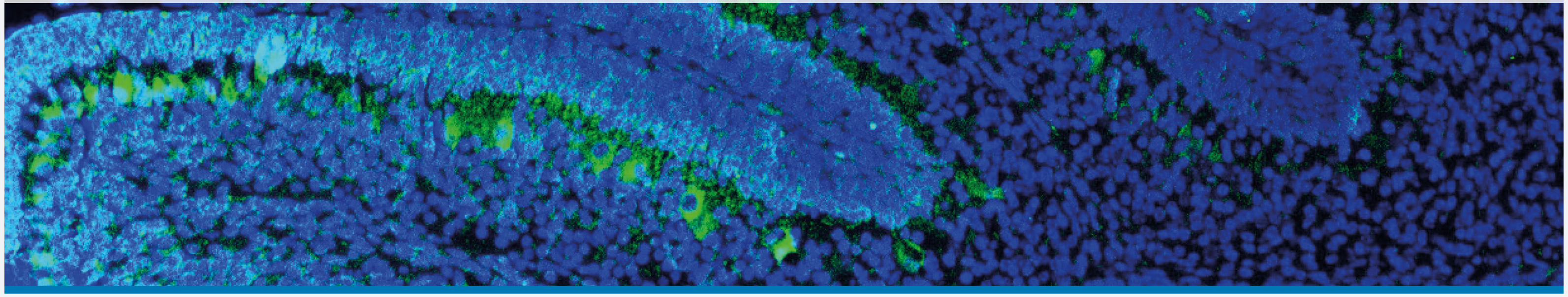
Achievements

We are building our lab and our team. Stay tuned…

Representative Publications

[1] Rossi L.F. et al., Nature, vol. 588, (no. 7839), pp. 648-652, 2020.
[2] Rossi L.F. et al., Frontiers in Cellular Neuroscience, vol. 12, 2018.
[3] Rossi L.F. et al., Nature Communications, vol. 8, (no. 1), 2017.
[4] Carandini M. et al., Journal of Neuroscience, vol. 35, (no. 1), pp. 53-63, 2015.
[5] Brondi M. et al., Frontiers in Molecular Neuroscience, (no. SEPTEMBER), 2012.

NANOTECHNOLOGIES FOR NEUROSCIENCES



Principal Investigator
Giancarlo Ruocco
CLN_S@Sapienza

Description

Our unit develops new technologies to study and tackle neurodegenerative and neurodevelopmental pathologies in a highly interdisciplinary manner. These technologies include:

i. Microscopes (Brillouin microscope, long working distance or high-resolution microscope, IR spectromicroscope);
ii. Diagnostic tools (early diagnosis of Alzheimer's disease (AD) via retinal imaging, animal-based cancer screening);
iii. Platforms (bioprinting, organoids, organ-on-chip) for personalized drugs, tests, and delivery; and
iv. Computational methods (biocomputation and AI-boosted imaging).

Our unit is the scientific pillar of two industrial Joint Labs (JL). The Crest Optics JL seeks to optimize and industrialize Brillouin microscopy. The D-tails JL seeks to develop new diagnostic tools for AD and breast/prostate cancer.

Achievements

Several of our patents are jointly owned by IIT and the JL companies.

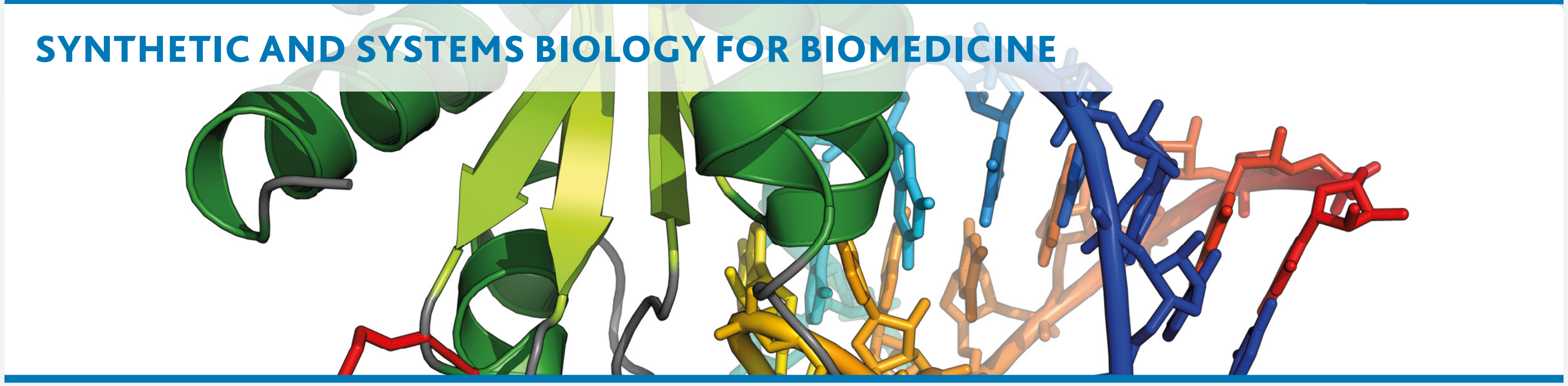
The PI is responsible for the following grants: an ERC SyG to study protein aggregation in neuropathology (ASTRA); an EIC Pathfinder Open to develop fast-acquisition Brillouin microscopy (ivBM); a PNRR-CNN3-SPOKE3 project to develop a bioprinted platform for Kabuki syndrome drugs; and other projects funded by EU- (MSCA, EIC), national bodies- (Regione Lazio, Regione Val d'Aosta, ASI) and charities and companies- (AIRC, Roche, ON, MTFB).

Our unit is part of the IIT iRNA initiative. We have also initiated projects with other IIT research units.

Representative Publications

[1] Leonetti M. et al., Proceedings of the National Academy of Sciences of the United States of America, vol. 118, (no. 21), 2021.
[2] Leonetti M. et al., Nature Communications, vol. 12, (no. 1), 2021.
[3] Fasciani A. et al., Nature Genetics, vol. 52, (no. 12), pp. 1397-1411, 2020.
[4] Prevedel R. et al., Nature Methods, vol. 16, (no. 10), pp. 969-977, 2019.
[5] Angelani L. et al., Proceedings of the National Academy of Sciences of the United States of America, vol. 115, (no. 35), pp. 8700-8704, 2018.

SYNTHETIC AND SYSTEMS BIOLOGY FOR BIOMEDICINE



Principal Investigator
Velia Siciliano
CABHC@CRIB

Description

Synthetic and Systems Biology Lab for Biomedicine (Synbio lab) applies computationally aided control engineering principles in order to develop the next generation of cell-based therapeutics and to generate advanced tools to interrogate biology.

We focus on foundations and applications, integrating synthetic circuits in order to:

i. Unravel the optimal design of synthetic networks with minimal impact on cell physiology;
ii. Develop automated tools to integrate high-throughput data and rapidly implement tissue-specific therapeutic switches; and
iii. Develop technologies in synergy with state-of-the-art methods for cell-based therapies.

The Synbio lab's core is our broad multidisciplinary environment, with expertise ranging from molecular biology to mathematics, and from engineering to immunology.

Achievements

We have worked at the forefront of foundational technologies for:

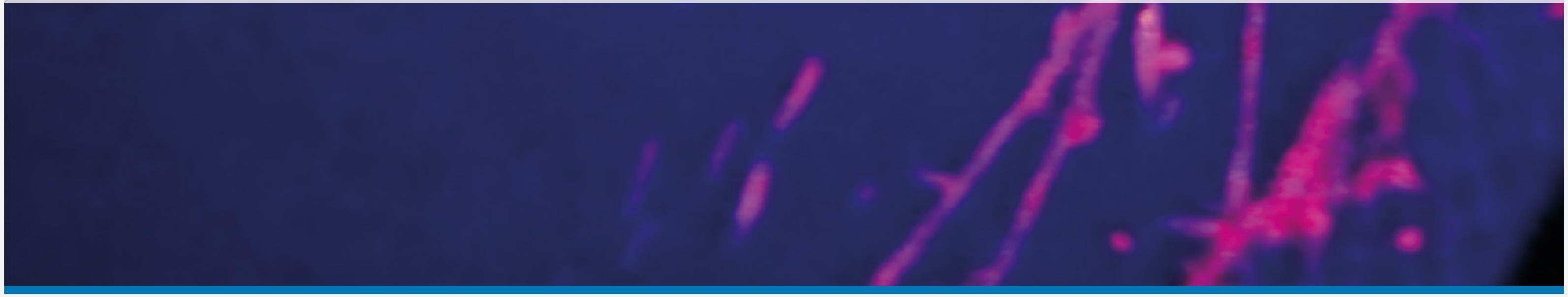
i. Developing tools for the transcriptional and post-transcriptional-based genetic reprogramming of engineered cells; and
ii. Laying the foundations to optimize the mammalian cell engineering pipeline, taking into account the impact of exogenous payloads on cell physiology.

This work will profoundly impact the engineering of cell-based immunotherapies, which is a key goal for our group.

Representative Publications

[1] Cella F. et al., Nucleic Acids Research, 2023.
[2] Di Blasi R. et al., Nature Communications, 2023.
[3] Frei T. et al., Nature Communications, vol. 11, (no. 1), 2020.
[4] Siciliano V. et al., Nature Communications, vol. 9, (no. 1), 2018.
[5] Cella F. et al., Nature Communications, vol. 9, (no. 1), 2018.

RNA SYSTEMS BIOLOGY



Principal Investigator
Gian Gaetano Tartaglia
CHT@Erzelli

Description

Our lab unites computational and experimental methods to delve into RNA's roles in health and disease. We have unveiled the Xist RNA interactome, explored the Fragile X Tremor Ataxia Syndrome-related regions, and investigated RNA partners in amyotrophic lateral sclerosis, offering therapeutic insights. Our focus is deciphering RNA-protein dynamics that are vital to understanding genomic functions and treating disorders. We are fascinated by toxic aggregation mechanisms and have spotlighted noncoding RNAs as protein-RNA interaction scaffolds. We have thus highlighted the transcript attributes that govern ribonucleoprotein assembly formation and phase separation. This is crucial for cellular biology and viral infections, creating new paths for comprehensive cellular event studies and therapeutic developments. Our integrated approach is set to unveil intricate RNA behaviors and interactions, fostering new understanding of diseases and treatment pathways.

Achievements

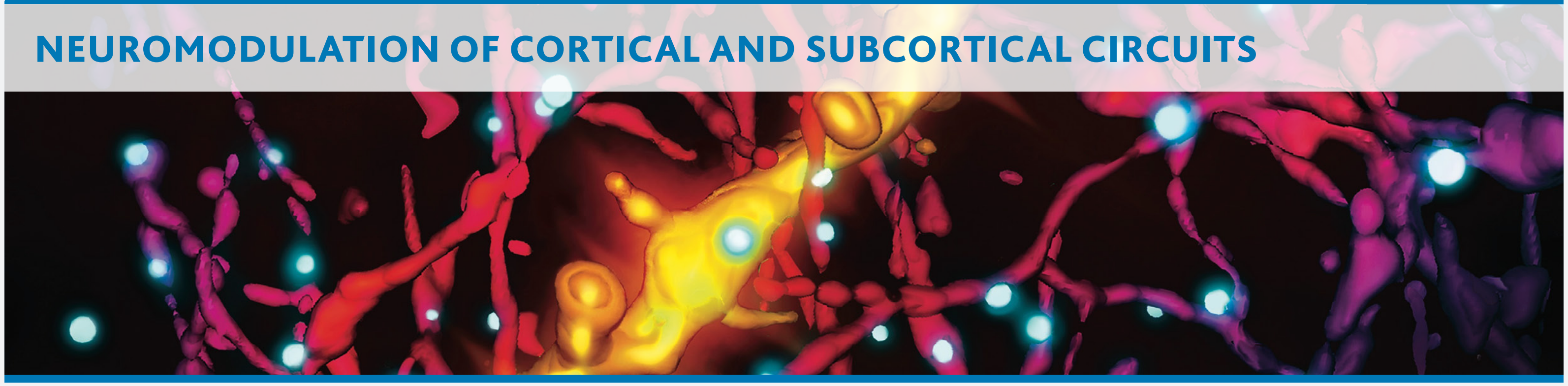
We have built algorithms to predict RNA structure and implemented methods for high-throughput predictions of protein interactions [1,2]. We have characterized the propensity of RNA-binding proteins to undergo phase separation, which is highly relevant for human disease [3,4].

We recently began using machine learning approaches to tackle statistical genetics problemsusing machine learning approaches [5]. We exploited the predictive power of our catRAPID algorithm for the de novo design of therapeutic/diagnostic RNA sequences (patent filed: IT 102022000009500 / IIT PT210613).

Representative Publications

[1] Arnal Segura M. et al., Alzheimer's and Dementia: Diagnosis, Assessment and Disease Monitoring, vol. 14, (no. 1), 2022.
[2] Cerase A. et al., Nature Structural and Molecular Biology, vol. 29, (no. 3), pp. 183-185, 2022.
[3] Zacco E. et al., Nature Communications, vol. 13, (no. 1), 2022.
[4] Armaos A. et al., Nucleic Acids Research, vol. 49, (no. 1), pp. W72-W79, 2021.
[5] Vandelli A. et al., Nucleic Acids Research, vol. 48, (no. 20), pp. 11270-11283, 2020.

NEUROMODULATION OF CORTICAL AND SUBCORTICAL CIRCUITS



Principal Investigator
Raffaella Tonini
CCT@Morego

Description

To adapt to an ever-changing environment and reach goals, the brain must learn to choose between different behavioral options. This behavioral flexibility is influenced by neuromodulatory systems that selectively report perceptual and motivational information. Neuromodulators act via specialized receptors localized on anatomically different pathways to shape neuron activity and synapse strength and plasticity. However, we understand little about how spatially and temporally diverse neuromodulatory signals converge to modulate information processing on a timescale relevant to behavior.

Our Research Unit aims to understand how the temporal dynamics of neuromodulatory signals shape interactions between brain regions for valence processing and motor control, to implement adaptive, flexible behavior, and to support the learning of inflexible action. Taking a mechanistic approach, we measure neuromodulator release and synaptic effects during behavior.

Achievements

The functional connectivity between the cortex and subcortical regions, including the basal ganglia, plays a major role in sensory-motor integration, reward-based learning, and action control.

We have made clear strides towards understanding how pathway-specific and cell-type-specific changes in bidirectional synaptic plasticity (i.e. potentiation or depression of synaptic strength) affect striatal circuit dynamics to drive motor and motivated behaviors, under physiological and pathological conditions (psychomotor disorders, including Parkinson's disease).

Representative Publications

[1] Boender A.J. et al., Biological Psychiatry, vol. 89, (no. 11), pp. 1045-1057, 2021.

[2] Alberio L. et al., Nature Methods, vol. 15, (no. 11), pp. 969-976, 2018.

[3] Cavaccini A. et al., Neuron, vol. 98, (no. 4), pp. 801-816.e7, 2018.

[4] Nazzaro C. et al., Nature Neuroscience, vol. 15, (no. 2), pp. 284-293, 2012.

GENETICS AND EPIGENETICS OF BEHAVIOR

Principal Investigator
Valter Tucci
CCT@Morego

Description

We explore sleep epigenetics, particularly genomic imprinting. This aspect of the parental origin of a gene has not previously been addressed in studies of sleep and circadian rhythms. Imprinting is a widely recognized concept in developmental biology. It involves the marking of specific regions across the genome, which leads to the expression of only one allele and, in the simplest imprinted loci, the transcriptional silencing of either the maternally or paternally inherited allele.

Our hypothesis is that imprinting has played a significant role in shaping the evolutionary trajectory of mammalian sleep in various ecological niches (Tucci, PLoS Genet., 2016; Tucci et al., Cell, 2019). Genomic imprinting is instrumental to studying sleep in our lab, where we have generated a suite of CRISPR-based technologies for epigenetic editing.

Achievements

Projects: Our ongoing research on Prader-Willi syndrome receives support from various funding agencies, including Telethon, FPWR, Lejeune Foundation, and Angelini.

In 2014, we identified a novel rare syndrome, and we are actively exploring new potential therapies.

Collaborations include Laura Cancedda at IIT's Brain Development and Disease Lab; Andrea Petretto at Gaslini Hospital; Fuat Balci at University of Manitoba; Anthony Isles at Cardiff University; and Francoise Muscatelli at INMED-INSERM.

Representative Publications

[1] Tinarelli F. et al., Epigenetics and Chromatin, vol. 14, (no. 1), 2021.

[2] Pace M. et al., Human Molecular Genetics, vol. 29, (no. 12), pp. 2051-2064, 2020.

[3] Pace M. et al., JCI insight, vol. 5, (no. 12), 2020.

[4] Tucci V. et al., Cell, vol. 176, (no. 5), pp. 952-965, 2019.

[5] Balzani E. et al., Nature Protocols, vol. 13, (no. 6), pp. 1331-1347, 2018.

RD: Nanomaterials

Research Units

Principal Investigators

VECTORIAL NANO-IMAGING

Principal Investigator
Antonio Ambrosio
CNST@PoliMi

Description

We create structured light with complex optical field patterns in a broad wavelength range using flat optical devices like metasurfaces. Metasurfaces use optically thin arrays of optical scatterers (e.g. nano-antennas) with sub-wavelength sizes and separations. They thus obtain a spatially varying optical response that molds optical wavefronts at will. Each nano-element of a metasurface can modulate the amplitude, phase and polarization of the transmitted light. This allows the realization of intensity patterns with inhomogeneous distributions of polarization directions.

We also develop state-of-the-art optical scanning probe microscopes for the imaging of complex optical fields with 3D nanometric resolution, as well as near-field imaging and spectroscopy of 2D materials, polymers, and nanostructured surfaces.

Achievements

Since our founding in 2020, we have created new paradigms in nanophotonics. We demonstrated the novel concept of shapeshifting metasurfaces that can morph into different designs. The implemented schemes have allowed us to develop new laser sources for parallelized processing and spatio-temporal light structuring.

in terms of scanning probe microscopy, we have focused on the imaging of excitonic and electrostatic features in dielectric and semiconductive 2D materials. For this, we have also implemented new nanospectroscopy techniques.

Representative Publications

[1] Piccardo M. et al., Nature Photonics, 2023.
[2] De Oliveira M. et al., ACS Photonics, 2023.
[3] Chiodini S. et al., ACS Nano, 2022.
[4] Oscurato S.L. et al., Laser and Photonics Reviews, vol. 16, (no. 4), 2022.
[5] Piccardo M. et al., Nature Photonics, vol. 16, (no. 5), pp. 359-365, 2022.

SMART MATERIALS

Principal Investigator
Athanassia Athanassiou
CCT@Morego

Description

Smart Materials is an interdisciplinary group that develops sustainable materials by focusing on their sources, means of production, and end of life. We develop and engineer biopolymeric composites for environmental protection and variable industrial applications. In line with the concept of upcycling in the circular economy, we investigate ways of processing renewable industrial residues, such as lignocellulosic biomass, oils, proteins, and paper, for reintroduction to the market as high added-value products. The physicochemical properties of these composites are tuned by chemistry and engineering. They can incorporate nanofillers or active principles to attain added properties like electrical conductivity, antioxidant activity, or controlled biodegradation. Our materials have applications in water remediation, wound management, coral protection, agricultural systems, green/flexible electronics, and packaging.

Achievements

Alkivio, our first spinoff, was founded in July 2022 with an investment from Novacart. Alkivio produces compostable biocomposites from paper waste. These can be used as substitutes for conventional plastics.

We have secured highly diversified external funds, including EU, industrial, institutional projects, and Joint Labs, of more than EUR 7 M in the last nine years.

Our PI is president of the Scientific Committee of the Competence Center for Economic, Ecological, and Social Sustainability at the University of Bolzano, and Advisory Board Member for H2020/IA/Bioplastics Europe.

Representative Publications

[1] Merino D. et al., Chemical Engineering Journal, vol. 454, 2023.

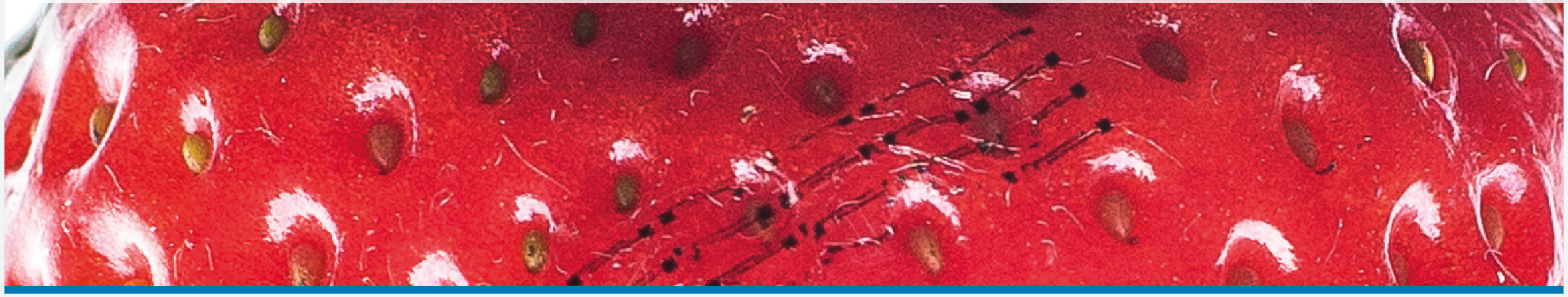
[2] Merino D. et al., Advanced Sustainable Systems, 2023.

[3] Cvek M. et al., ACS Applied Materials and Interfaces, vol. 14, (no. 12), pp. 14654-14667, 2022.

[4] Papadopoulou E.L. et al., ACS Applied Materials and Interfaces, vol. 11, (no. 34), pp. 31317-31327, 2019.

[5] Pignatelli C. et al., Acta Biomaterialia, vol. 73, pp. 365-376, 2018.

PRINTED AND MOLECULAR ELECTRONICS



Principal Investigator
Mario Caironi
CNST@PoliMi

Description

Our goal is to deliver new solutions for sustainable and pervasive electronics. We do this by:

i. Taking abundant nontoxic materials that are processable from solution at low temperatures;
ii. Using energy-efficient additive printing techniques for their manufacturing; and
iii. Reducing their environmental impact.

We are leading the development of printed organic electronics operating at high frequency, greatly expanding their applications for sustainable wireless sensors and Internet of Things. We are also developing large-area printed organic biosensors for point-of-care applications. We recently devised new transducers to record action potentials of electrogenic cells for future bio-organic interfaces. In the emerging field of edible electronics, we seek to develop nontoxic edible electronic systems that are digested or even metabolized after performing their function. Our work thus has broad applications in healthcare, food safety, and green soft robotics.

Achievements

We have secured competitive funding for our flagship projects (e.g. high-frequency printed electronics, edible electronics), including two ERC projects (StG HEROIC 2015-2020, CoG ELFO 2020-2025).

in technology transfer, we have established two joint labs and several sponsored research agreements. In 2016, the startup Ribes Tech srl was founded to commercialize printed plastic indoor photovoltaics. In 2019, the startup Fleep Technologies srl was founded to commercialize printed microelectronics systems.

Representative Publications

[1] Ilic I.K. et al., Advanced Materials, 2023.
[2] Genco E. et al., Advanced Materials, 2023.
[3] Kyndiah A. et al., Sensors and Actuators, B: Chemical, vol. 393, 2023.
[4] Lamanna L. et al., Advanced Materials Technologies, vol. 8, (no. 1), 2023.
[5] Perinot A. et al., Advanced Science, vol. 8, (no. 4), 2021.

ADVANCED CHARACTERIZATIONS AND OPTIMIZED FUNCTIONAL MATERIALS FOR ENERGETIC TRANSITION

Principal Investigator
Angelica Chiodoni
CSFT@PoliTo

Description

The demand for more and more sustainable and inexpensive technologies for energy transition and circular economy requires fine tuning the properties of functional materials to maximize their capability to be active, sustainable, at low or reduced costs, and with a long-term lifetime.

To do so, in-situ/operando characterization approaches are the key to design optimized functional materials. In particular, the observation of such materials as while they work in simulated-device conditions, through e.g., transmission electron microscopy, X-ray diffraction, Raman and IR spectroscopies, X-ray photoelectron spectroscopy, will help shed light into reaction mechanisms and materials modification as a function of the experimental conditions.

Achievements

The new Research Unit is going to be launched in March 2024.

Together with the other Research Units, it will contribute synergistically to the objectives of the Center for Sustainable Future Technologies, providing new insights into functional materials, with a view to using them for energy transition applications.

Representative Publications

[1] Monti N.B.D. et al., ACS Applied Energy Materials, vol. 5, (no. 12), pp. 14779-14788, 2022.
[2] Bejtka K. et al., Materials, vol. 14, (no. 9), 2021.
[3] Bejtka K. et al., ACS Applied Energy Materials, vol. 2, (no. 5), pp. 3081-3091, 2019.
[4] Chiodoni A. et al., International Journal of Hydrogen Energy, vol. 44, (no. 9), pp. 4432-4441, 2019.
[5] Munoz-Tabares J.A. et al., Nanoscale, vol. 8, (no. 12), pp. 6866-6876, 2016.

SMART BIO-INTERFACES

Principal Investigator
Gianni Ciofani
CMI@SSSA

Description

Since 2017, we have been working on smart nanomaterials for nanomedicine, in vitro models, and biology in altered gravity conditions. In particular, we develop and exploit physically active nanoparticles and nanostructured materials that can provide appropriate instructive cues to cells and tissues. Using smart nanomaterials to remotely control cellular functions is a biomanipulation approach with unprecedented potential for medical applications ranging from cancer therapy to tissue engineering. By actively responding to external stimuli, smart nanomaterials act as real nanotransducers that mediate and/or convert different forms of energy into physical and chemical cues in order to foster specific cell behaviors. We thus propose a new paradigm for nanomedicine that exploits the intrinsic properties of nanomaterials as active devices rather than as passive structural units or carriers for medication.

Achievements

We have secured around EUR 6 M in funding, including a Starting Grant (2016) and two Proof-of-Concept Grants (2018, 2022) from the ERC. Thanks to the Italian Space Agency and the European Space Agency, we conducted experiments on the International Space Station in 2017, 2019, and 2022. Our real-scale model of the blood-brain barrier was highlighted by the ERC Annual Report as one of the most disruptive results of 2018.

In 2022, we launched a start-up to exploit the antioxidant properties of natural extracts for nutraceutical and cosmetic applications.

Representative Publications

[1] De Pasquale D. et al., Advanced healthcare materials, 2023.
[2] Pucci C. et al., Acta Biomaterialia, vol. 139, pp. 218-236, 2022.
[3] Marino A. et al., Small, vol. 14, (no. 6), 2018.
[4] Marino A. et al., ACS Nano, vol. 11, (no. 3), pp. 2494-2505, 2017.

2D MATERIALS ENGINEERING

Principal Investigator
Camilla Coletti
CNI@NEST

Description

We focus on 2D materials, atomically thin layers that display extraordinary electrical, mechanical, optical, and thermal properties and host novel enticing physical phenomena. We develop solutions to obtain 2D materials and their vertical stacks over large areas, with excellent crystalline quality and controlled stacking angle. We have extensive expertise in chemical vapor deposition synthesis, a technique that yields highly crystalline 2D materials.

We investigate the fundamental properties of the synthesized 2D materials with advanced characterization techniques. We tailor their properties, and assess their most promising fields of applications. We nurture strong collaborations with research units and companies around the globe to develop novel energy-efficient communication technologies, demonstrate high-performance electronics and sensing, and devise future quantum applications.

Achievements

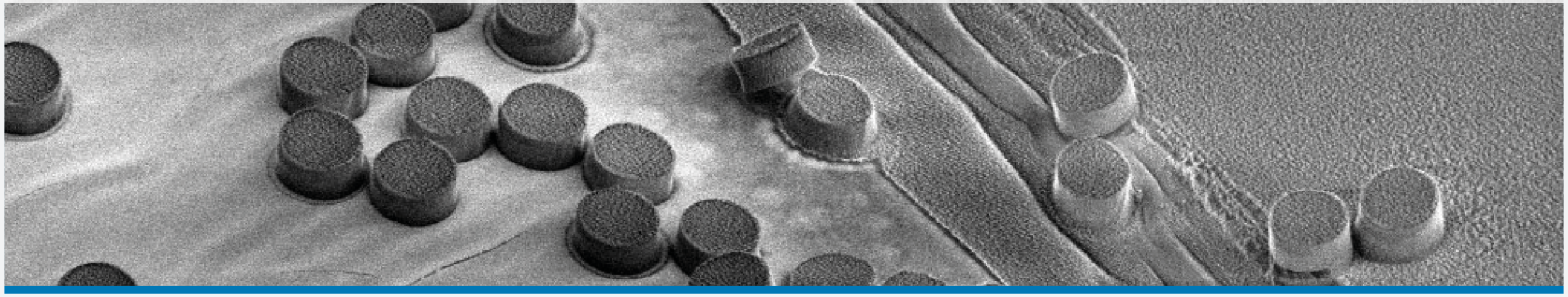
From 2018 to 2023, we secured external funding of more than EUR 6.5 M (from national and international competitive calls and industrial contracts).

We also published more than 140 scientific papers, three book chapters, and delivered around 60 invited talks at international conferences and workshops.

Representative Publications

[1] Pace S. et al., ACS Nano, vol. 15, (no. 3), pp. 4213-4225, 2021.
[2] Giambra M.A. et al., ACS Nano, 2021.
[3] Pezzini S. et al., Nano Letters, vol. 20, (no. 5), pp. 3313-3319, 2020.
[4] Convertino D. et al., Nano Letters, vol. 20, (no. 5), pp. 3633-3641, 2020.
[5] Mishra N. et al., Small, vol. 15, (no. 50), 2019.

PLASMON NANOTECHNOLOGIES



Principal Investigator
Francesco De Angelis
CCT@Morego

Description

We design and make nanostructures for optics, electronics, and mechanics applied to molecular sensing, with a focus on biomolecules and living tissues. Our multidisciplinary unit of 15-20 people includes physicists, chemists, biotechnologists, pharmacologists. and engineers.

Our two research directions seek to converge in the long term to control biological systems at the nanoscale:

i. We develop new sensing strategies to detect one or a few molecules in complex environments and/or electrical/mechanical signals at the nanoscale; and
ii. We interface multiomic detectors with living tissues to monitor biological environments from single cells to networks. In other words, we develop hybrid interfaces between cells and solid-state devices, with potential applications in biology and medicine (prosthetics).

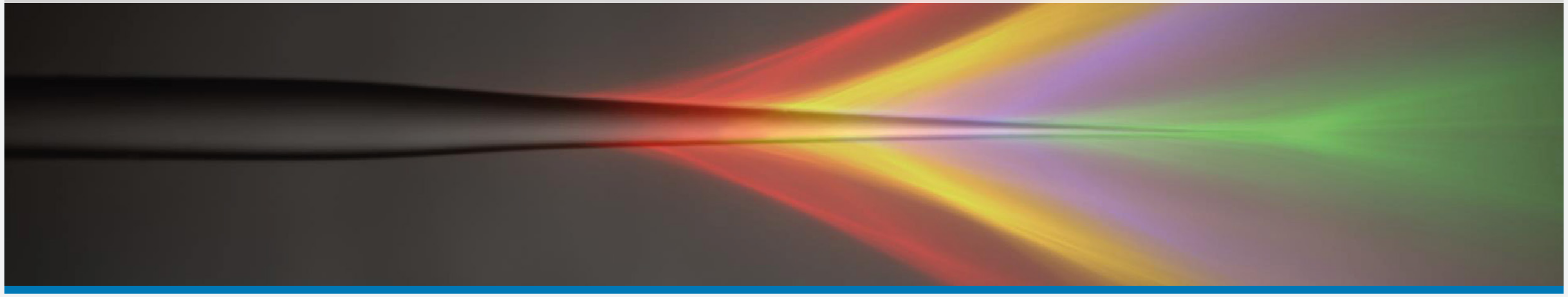
Achievements

We have developed different methods for monitoring electrical activities in human cells (cardiac and brain cells) in vitro with low or no perturbation (zero invasiveness). Our achievements include several European projects, high-quality papers, and patents. This resulted in a pharmacological screening startup in 2021. We are developing new genomics and proteomics tools, based on plasmonic nanodevices, nanofluidics, and Raman spectroscopy. We have shown it is possible to discriminate single nucleotides in a DNA molecule, or single amino acids in a protein.

Representative Publications

[1] Iarossi M. et al., Advanced Functional Materials, 2023.
[2] Barbaglia A. et al., Advanced Materials, vol. 33, (no. 7), 2021.
[3] Huang J. et al., Nature Communications, 2019.
[4] Dipalo M. et al., Nature Nanotechnology, 2018.
[5] Dipalo M. et al., Nano Letters, vol. 17, (no. 6), pp. 3932-3939, 2017.

SMART HEALTHCARE TECHNOLOGIES



Principal Investigator
Massimo De Vittorio
CBN@UniLe

Description

We develop advanced technologies for monitoring and controlling behavior and health on the molecular, cellular, organ, and whole-body scales, with temporal and spatial resolution.

We seek to enable prediction and early diagnostics by collecting pathophysiological signals and, simultaneously, to enable the control and manipulation of behavior through actuators.

i. Our technological platform includes: multifunctional brain probes for recording brain activity and for neuromodulation in animal models of brain disorders;
ii. Piezoelectric smart patches for monitoring sounds and mechanical deformations of muscles, organs, and arteries on skin; and
iii. Ingestible electronics for sensing along the gastrointestinal tract and for wirelessly controlling drug delivery on demand.

Achievements

Massimo De Vittorio has published more than 400 manuscripts in international journals. He has received more than 60 invitations as keynote or plenary speaker. He is the founder/advisor of three startup companies, inventor of 14 international patents, and founder of the International Micro and Nano Engineering society (iMNEs). Since 2012 as PI at IIT, he has secured research and industrial grants worth EUR 20 M. He was recently awarded the Novo Nordisk 2023 Research Laureate award.

Representative Publications

[1] Spagnolo B. et al., Nature Materials, vol. 21, (no. 7), pp. 826-835, 2022.
[2] Natta L. et al., ACS Sensors, vol. 6, (no. 5), pp. 1761-1769, 2021.
[3] Mariello M. et al., Advanced Functional Materials, vol. 31, (no. 27), 2021.
[4] Pisanello F. et al., Nature Neuroscience, vol. 20, (no. 8), pp. 1180-1188, 2017.

NANOTECHNOLOGY FOR PRECISION MEDICINE

Principal Investigator
Paolo Decuzzi
CCT@Morego

Description

The Nanotechnology for Precision Medicine Lab was established by Prof. Decuzzi in July 2015 with the support of the ERC CoG POTENT.

Our mission is to:

i. Design biomedical systems that integrate a wide array of therapeutic and imaging agents to detect and treat medical conditions including brain and breast cancers, osteoarthritis, stroke, and various neurological disorders;
ii. Conceive and fabricate microfluidic chips to test nanomedicines and unveil the intricate biophysical mechanisms that regulate disease progression;
iii. Develop multiscale computational models to optimize the performance of drug delivery systems using physics-instructed machine learning tools;
iv. Engage in dissemination activities at the intersection of engineering and biomedical sciences; and
v. Foster the professional growth of lab members within a diverse and multidisciplinary environment.

Achievements

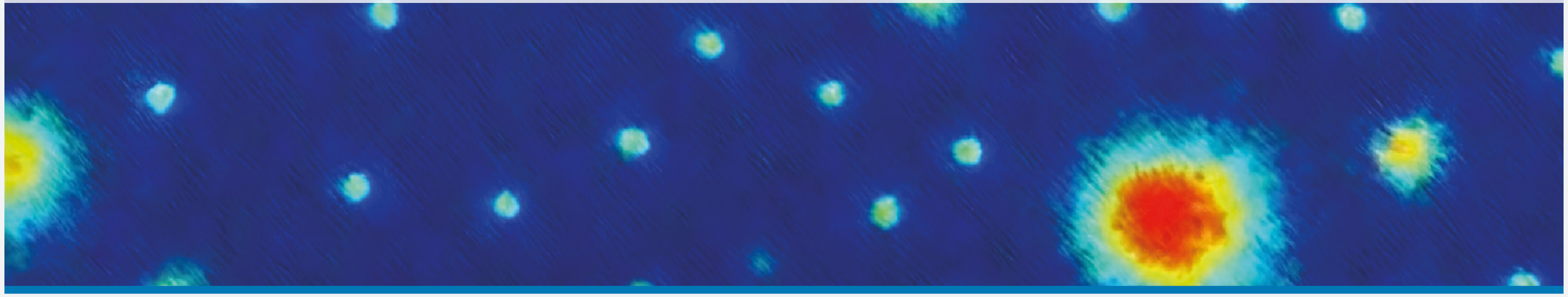
We have realized and preclinically validated drug delivery systems over multiple scales. These include lipid nanoparticles, microgels, and biodegradable implants.

Rather than confining ourselves to a specific technology, we develop diverse systems to address specific unmet medical needs. Our most recent achievements include: microMESH to treat gliomas; microPlates to manage osteoarthritis; methyl palmitate nanoparticles to boost nanomedicine performance; and hydrogel particles to treat pulmonary and liver metastases.

Representative Publications

[1] Palange A.L. et al., Advanced Science, 2023.
[2] Ozkan H. et al., Drug Delivery and Translational Research, vol. 13, (no. 2), pp. 689-701, 2023.
[3] Di Mascolo D. et al., ACS Nano, vol. 17, (no. 15), pp. 14572-14585, 2023.
[4] Pannuzzo M. et al., Biomacromolecules, vol. 23, (no. 11), pp. 4678-4686, 2022.
[5] Di Mascolo D. et al., Nature Nanotechnology, vol. 16, (no. 7), pp. 820-829, 2021.

PHOTONIC NANOMATERIALS



Principal Investigator
Francesco Di Stasio
CCT@Morego

Description

Founded in 2020, Photonic Nanomaterials' long-term goal is to combine innovative light sources based on nanomaterials with other optical components for the next generation of integrated photonic systems. To advance the field of photonics, it is critical to develop novel and small-footprint light-emitting devices.

Colloidal semiconductor nanocrystals have advantageous properties for making both classical and quantum light sources (i.e. single photon emitters), which can be coupled with state-of-the-art photonic architectures. We therefore study and develop these light-emitting devices, using colloidal chemistry, top-down nanofabrication approaches, and advanced optical characterization techniques.

Achievements

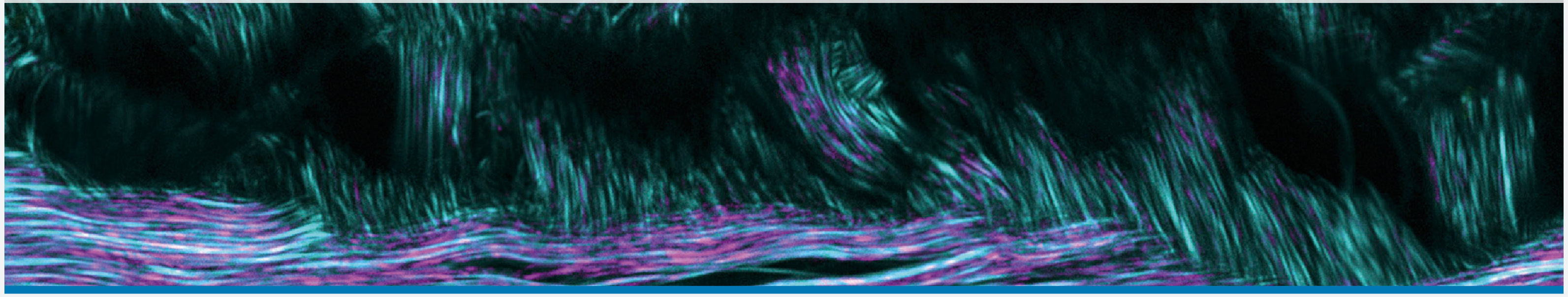
Our breakthroughs beyond the state of the art include:

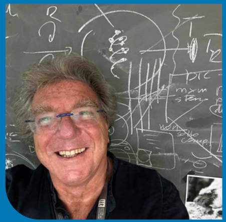
i. We obtained large arrays of nanocrystals (NCs) with controlled positioning via capillary assembly on a patterned substrate. The NC array was achieved via an interplay of bottom-up and top-down approaches that demonstrate our interdisciplinarity; and
ii. We developed novel infrared-emitting nanocrystals and implemented them in light-emitting diodes. The devices demonstrate record performance in terms of efficiency in both therapeutic (650-1350 nm) and telecommunication (1350 – 1550 nm) windows.

Representative Publications

[1] Barelli M. et al., ACS Photonics, 2023.
[2] Bahmani Jalali H. et al., ACS Energy Letters, pp. 1850-1858, 2022.
[3] De Franco M. et al., Optical Materials: X, vol. 13, 2022.
[4] Bahmani Jalali H. et al., Chemical Society Reviews, vol. 51, (no. 24), pp. 9861-9881, 2022.
[5] De Franco M. et al., ACS Energy Letters, vol. 7, (no. 11), pp. 3788-3790, 2022.

NANOSCOPY & NIC@IIT





Principal Investigator
Alberto Diaspro
CHT@Erzelli

Description

We design and develop technologies and instruments for advanced multimodal super-resolved fluorescence and label-free optical microscopy with molecular resolution and dynamics boosted by AI. Our research is applied to neurodegenerative and oncological diseases. Our main optical methods are confocal, two-photon, light-sheet, super-resolved, SHG/THG, nonlinear pump-probe, phase, Mueller matrix, photoacoustics, expansion, and quantum optical microscopy.

We use confocal laser scanning, spatial array confocal and image scanning sample interrogation, and single-photon solid-state detectors. One ambitious goal is to develop an artificial microscope that forms a molecular fluorescence image from pure label-free data, creating new perspectives for diagnostics. We collaborate with Nikon Industries on technology transfer via NIC@IIT and the NIKON-IIT R&D.

Achievements

We have secured funding and played scientific roles in the following programs: National Center for Gene Therapy and Drugs based on RNA Technology; NQSTI National Quantum Science and Technology Institute; Eurobioimaging; and Molecular-Scale Biophysics Research Infrastructure.

We are working with the Molecular Microscopy and Spectroscopy Lab to realize the newest Nikon Spatial Array Confocal Microscope.

Our scientific output includes about 400 publications in peer-reviewed journals and 30 patents.

Our outreach includes the Chair of Focus on Microscopy 2024 and the 11th International Weber Symposium 2025.

Representative Publications

[1] Jadavi S. et al., Nanoscale, 2023.
[2] Tortarolo G. et al., Nature Communications, vol. 13, (no. 1), 2022.
[3] Zunino A. et al., ACS Photonics, vol. 8, (no. 11), pp. 3385-3393, 2021.
[4] Cosentino M. et al., Science advances, vol. 5, (no. 6), 2019.
[5] Castello M. et al., Nature Methods, vol. 16, (no. 2), pp. 175-178, 2019.

ELECTRON SPECTROSCOPY AND NANOSCOPY

Principal Investigator
Giorgio Divitini
CCT@Morego

Description

The properties of matter at the nanoscale are crucial to the behavior of materials and devices all around us. For example, all modern electronics are enabled by very low concentrations of dopant elements in silicon.

We study the correlation between local structure, composition, and behavior at the atomic scale. We focus on materials relevant for the energy transition (photovoltaics, lighting, energy storage, catalysis). Using spectroscopic techniques, we can access local optical properties, obtaining information on the fundamental nature of materials and on the operation of prototype devices. We use various tools to do this, including a state-of-the-art, aberration-corrected scanning transmission electron microscope, enabling the visualization and identification of individual atomic columns.

Our studies push the boundaries of electron microscopy, developing new approaches to data acquisition and processing, including implementing machine learning algorithms.

Achievements

We have commissioned a state-of-the-art transmission electron microscope, which allows us to study structure and chemical composition at the atomic scale.

We have built protocols and expertise to study challenging materials that are key to several applications in the field of energy. Thanks to funding from the Italian Space Agency, we are developing perovskite-based scintillators for space applications. We also contribute to the growth of expertise in electron microscopy in Italy and the EU by organizing a yearly workshop with international speakers.

Representative Publications

[1] Zhu D. et al., Advanced Materials, 2023.

[2] Livakas N. et al., Journal of the American Chemical Society, vol. 145, (no. 37), pp. 20442-20450, 2023.

[3] Lomonosov V. et al., Nanoscale, 2023.

[4] Moreira M. et al., Microscopy and Microanalysis, vol. 28, (no. 3), pp. 723-731, 2022.

[5] Kosasih F.U. et al., Microscopy Research and Technique, vol. 85, (no. 6), pp. 2351-2355, 2022.

ELECTRON CRYSTALLOGRAPHY

Principal Investigator
Mauro Gemmi
CMI@SSSA

Description

For any crystalline material, whether organic, inorganic, or of biological origin, the atomic structure is the starting point for identifying, understanding, und improving the material's properties. We develop methods to determine how atoms are arranged in a nanocrystalline material.

This can be achieved with a single crystal electron diffraction experiment, in which the reciprocal space of a single nanocrystal is reconstructed in 3D from a sequence of electron diffraction patterns, which are recorded while the crystal is rotated around the axis of the sample holder (3DED).

Thanks to a dedicated experimental setup, the crystal can be illuminated by a few electrons and the entire experiment can be performed in a few seconds. We can thus investigate the crystal structure of challenging beam-sensitive materials, such as metallorganic frameworks and pharmaceuticals, and determine their crystal structure.

Achievements

We have established a state-of-the-art facility to collect 3DED data from any type of nanocrystalline material. As a result, our researchers have solved the crystal structure of orthocetamol, the first unknown pharmaceutical compound ever solved by 3DED.

They have also determined the first new protein polymorph ever refined with 3DED data. This was a monoclinic structure of hen egg-white lysozyme. The Research Unit is now leading the development of 3D electron diffraction for the next few years as Coordinator of the EU-funded NanED ITN project.

Representative Publications

[1] Romagnoli L. et al., Chemistry of Materials, vol. 35, (no. 4), pp. 1818-1826, 2023.

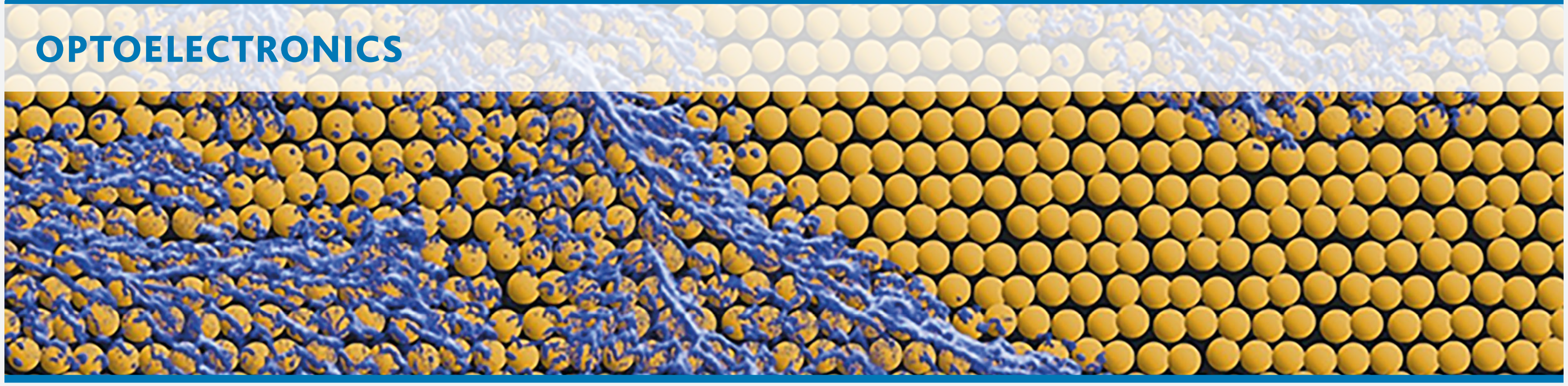
[2] Andrusenko I. et al., International Journal of Pharmaceutics, vol. 608, 2021.

[3] Gemmi M. et al., ACS Central Science, vol. 5, (no. 8), pp. 1315-1329, 2019.

[4] Lanza A. et al., IUCrJ, vol. 6, pp. 178-188, 2019.

[5] Andrusenko I. et al., Angewandte Chemie - International Edition, vol. 58, (no. 32), pp. 10919-10922, 2019.

OPTOELECTRONICS



Principal Investigator
Roman Krahne
CCT@Morego

Description

We investigate the optical and electronic properties of nanomaterials such as semiconductor (nano)crystals, metal nanoparticles and nanostructures, 2D lattices, and hybrid organic-inorganic systems. Our interests range from plasmonics, photonics, and metamaterials to single-molecule spectroscopy. We use the resulting insights to develop novel concepts for optoelectronic applications in light emission and manipulation, sensing, and information technologies, and to test these in proof-of-concept devices.

We are particularly interested in hybrid organic/inorganic metal halide perovskites. Thanks to the high tunability of their properties via composition and structure, they are very appealing for applications in light emission and energy conversion. We integrate these emerging materials with photonic and electronic structures to modulate and design their optical properties. Our group is involved in several European projects that target novel technologies and training.

Achievements

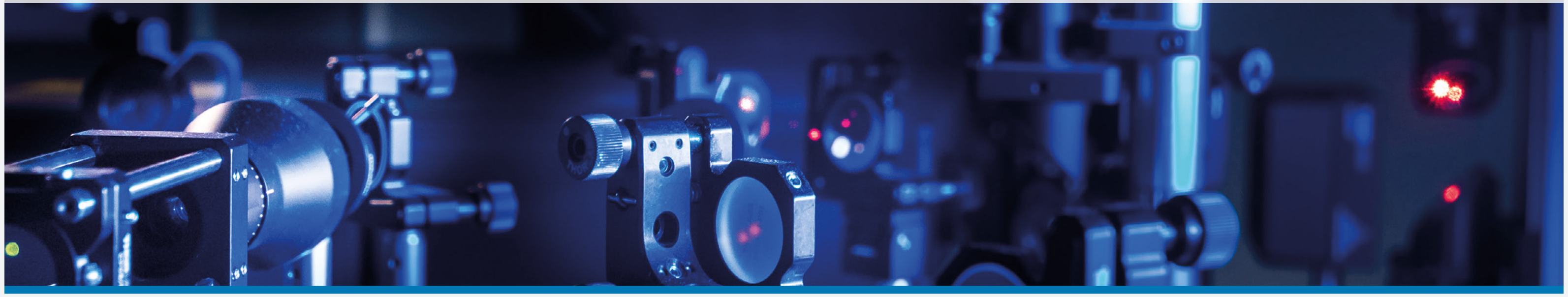
In photonics, we have:

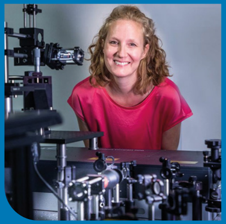
i. Designed ultrathin metal-dielectric nanocavities as metamaterials with vanishing dielectric permittivity, which present a versatile platform for light emission enhancement, sensing, and ultrafast optical switches designed plasmonic metasurfaces for near-field modulation, which allow light concentration and dynamic optical trapping on chip
ii. Developed sustainable photonic crystals and metasurfaces in biodegradable cellulose films that show structural colors. In emerging optoelectronic materials, we have obtained key insights into the photophysics of layered perovskites.

Representative Publications

[1] Lin M.-L. et al., Small, vol. 18, (no. 15), 2022.
[2] Abiedh K. et al., Advanced Optical Materials, vol. 10, (no. 3), 2022.
[3] Dhanabalan B. et al., ACS Nano, vol. 14, (no. 4), pp. 4689-4697, 2020.
[4] Caligiuri V. et al., Nano Letters, vol. 19, (no. 5), pp. 3151-3160, 2019.
[5] Miscuglio M. et al., ACS Nano, vol. 13, (no. 5), pp. 5646-5654, 2019.

FUNCTIONAL NANOSYSTEMS





Principal Investigator
Ilka Kriegel
CCT@Morego

Description

We target carbon neutrality and green energies, particularly noncritical raw materials. We conduct basic materials science by preparing new materials, studying fundamental light-matter interactions, and establishing functional devices.

We seek to explore novel mechanisms to convert and store the sun's energy via the direct light-driven charging of supercapacitors or supercapacitor-like device units. We also address photochemistry challenges, such as CO2 reduction. These topics are important for achieving the European Commission's targets, as outlined in the European Green Deal, and will also play a major role in the new Strategic Plan.

Achievements

Established in January 2020 with the 2019 ERC Starting Grant Light-DYNAMO, we have since attracted two ERC POC projects (2021 CONDINKS, 2023 STORE-LIGHT), and an FET proactive project LIGHT-CAP (as Coordinator).

Two of our postdocs have secured Marie Curie Postdoctoral Hlobal Fellowships (2021 INSTRINSIC, 2022 2DTWIST).

Representative Publications

[1] Asaithambi A. et al., Chemical Communications, 2023.
[2] Ghini M. et al., Nature Communications, vol. 13, (no. 1), 2022.
[3] Asaithambi A. et al., Advanced Optical Materials, vol. 10, (no. 14), 2022.
[4] Ghini M. et al., Nanoscale Advances, vol. 3, (no. 23), pp. 6628-6634, 2021.

NANOMATERIALS FOR ENERGY AND LIFESCIENCE

Principal Investigator
Guglielmo Lanzani
CNST@PoliMi

Description

Our research seeks to induce light sensitivity in living cells, organs, or tissue. We introduce phototransducers that establish functional abiotic/biotic interfaces. These harvest light energy and transduce it into a bioelectrical signal that eventually elicits a biological response. The ultimate goal is to realize light-driven human-machine interfaces for applications in regenerative medicine, prosthetics, and hybrid robotics.

Our studies have broad implications for robotics and life science, and could lead to revolutionary applications, such as prostheses for patients with paralysis, amputations, or neurodegenerative disorders. For example, we developed a retinal prosthesis in collaboration with NSYN and the Ospedale S. Cuore Negrar . Our interfaces can also be exploited in hybrid soft robotics with biotic components.

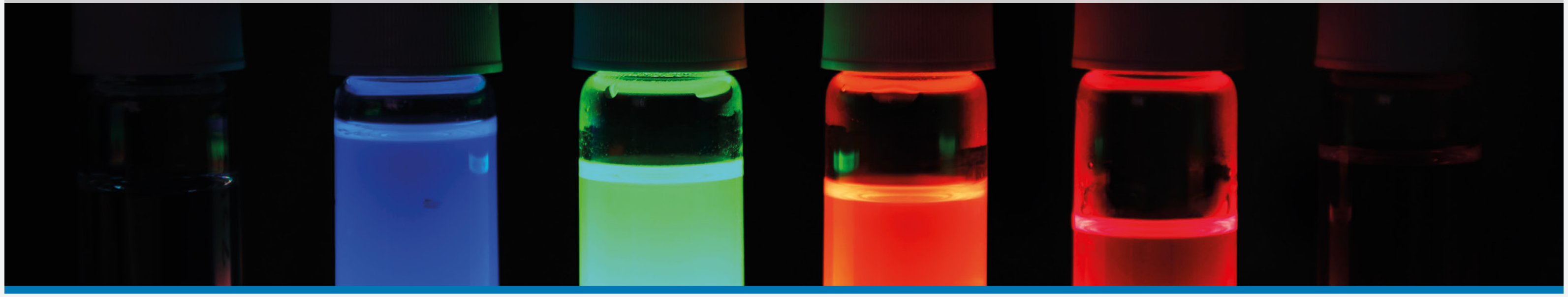
Achievements

We have established a new paradigm for cell optostimulation, pioneering the use of organic semiconductors as functional abiotic/biotic interfaces. We have developed a retina prosthesis that restores light sensitivity and visual acuity following implantation in blind rats. This prosthesis was developed in collaboration with Fabio Benfenati (for neurophysiological studies) and the eye surgeon Grazia Pertile (for clinical work on the animal model). We have also demonstrated that phototransducers can be used to stimulate cardiac and skeletal muscle cells.

Representative Publications

[1] de Souza-Guerreiro T.C. et al., Advanced Science, 2023.
[2] Benfenati F. et al., Nature Reviews Materials, vol. 6, (no. 1), 2021.
[3] Paterno G.M. et al., Advanced Science, vol. 7, (no. 8), 2020.
[4] DiFrancesco M.L. et al., Nature Nanotechnology, vol. 15, (no. 4), pp. 296-306, 2020.
[5] Maya-Vetencourt J.F. et al., Nature Nanotechnology, vol. 15, (no. 8), pp. 698-708, 2020.

NANOCHEMISTRY



Principal Investigator
Liberato Manna
CCT@Morego

Description

Colloidal inorganic nanocrystals are crystals that are a few nanometers in size, stabilized by organic ligands. Their great versatility makes them one of the most exploited nanomaterials. A rational synthetic approach to nanocrystals is therefore needed to meet the growing demand for nanomaterials. We seek to tune their optical, electronic, and catalytic features for application in various fields of science and technology. Our group also targets many basic science aspects of colloidal nanocrystals, including their synthesis, assembly, and chemical and structural transformations.

One important aspect of our work is to develop robust protocols for synthesizing colloidal nanocrystals so they can be easily reproduced by other groups. The reliability of our protocols has enabled a series of studies on nanocrystal properties and created new research avenues.

Achievements

We have:

i. Developed complex colloidal nanocrystals of II-VI semiconductors, studied their optical and electronic properties, and tested them in devices (polarized displays, LEDs, lasers).
ii. Conducted pioneering studies in cation exchange in nanocrystals and developed non-noble-metal-based nanoparticles.
iii. Advanced the synthesis of halide perovskite and perovskite-related nanocrystals, studied their surface properties, stability, and structural and compositional transformations, and exploited them in various optoelectronic devices.
iv. Developed the synthesis of III-V (InAs) nanocrystals and related cores/shells.

Representative Publications

[1] Toso S. et al., Nature Communications, vol. 13, (no. 1), 2022.
[2] Imran M. et al., Journal of the American Chemical Society, 2018.
[3] Akkerman Q.A. et al., Nature Energy, vol. 2, (no. 2), 2017.
[4] Akkerman Q.A. et al., Journal of the American Chemical Society, vol. 137, (no. 32), pp. 10276-10281, 2015.
[5] Dorfs D. et al., Journal of the American Chemical Society, vol. 133, (no. 29), pp. 11175-11180, 2011.

NANOMATERIALS FOR BIOMEDICAL APPLICATIONS

Principal Investigator
Teresa Pellegrino
CCT@Morego

Description

We develop novel materials on the nanoscale, mesoscale, and microscale, focusing on colloidal nanoparticles (NPs) for biomedical applications. Our main activities are the scalable synthesis of magnetic NPs with control over size, shape, crystallinity, and chemical composition, and heir assembly within submicrometer and micrometer particles of polymeric or inorganic origin (silica, carbonate structures), controlling their chemical and physical properties.

We aim to develop materials for biomedical applications such as cancer therapy and diagnosis, neuronal interactions and diseases, and opto-imaging.

We develop gram-scale methods to synthesize shape-control magnetic NPs (i.e. nanocubes, nanostars, Rubik-like clusters) and assemble them in chain 2D and 3D polymer or porous silica materials. These have magnetic hyperthermia applications in tumor therapy. We encapsulate Perovskites-NPs to have emitting beads in water.

Achievements

We have:

i. Developed cation/anion exchange protocols for Cu64 radio-insertion in semiconductor NPs for radiotherapy, photo- hyperthermia, or magnetic-hyperthermia, and for obtaining emitting beads.
ii. Used the cells of cancer patients in vitro and murine tumor models in vivo to test the efficacy of our materials for phototherapy, magnetic therapy, and radiotherapy. Our methods include tumor-initiating tests and biodistribution studies. For instance, we grew a thermoresponsive polymer on magnetic NPs. As demonstrated in preclinical studies, this allowed us to combine magnetic hyperthermia with targeted and heat-mediated chemotherapy.

Representative Publications

[1] Gavilan H. et al., Nature Protocols, 2023.
[2] Avugadda S.K. et al., ACS Nano, vol. 16, (no. 9), pp. 13657-13666, 2022.
[3] Gavilan H. et al., Chemical Society Reviews, vol. 50, (no. 20), pp. 11614-11667, 2021.
[4] Avellini T. et al., Advanced Functional Materials, 2020.
[5] Balakrishnan P.B. et al., Advanced Materials, vol. 32, (no. 45), 2020.

ADVANCED MATERIALS FOR OPTOELECTRONICS

Principal Investigator
Annamaria Petrozza
CNST@PoliMi

Description

Since 2013, Advance Materials for Optoelectronics at the Center for Nano Science and Technology in Milan has focused on developing advanced and sustainable optoelectronic technologies for extensive integration into everyday life.

Achievements

The group is internationally recognized for its pioneering studies on the fundamental properties and technological development of metal halide perovskite semiconductors for optoelectronic applications.

We made key contributions to understanding how the chemical and structural properties of this large materials platform affect their electronic properties and the stability of their devices.

Representative Publications

[1] Motti S.G. et al., Nature Photonics, 2019.

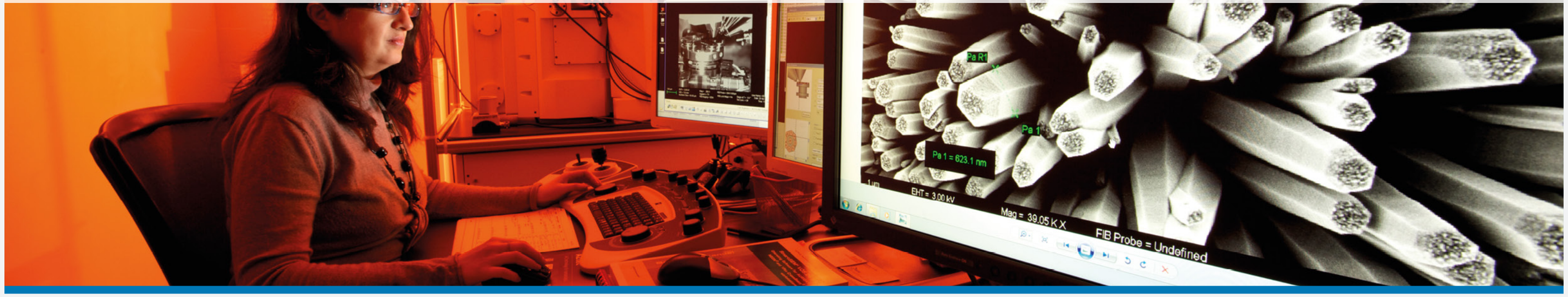
[2] Kim M. et al., Energy and Environmental Sciences, vol. 11, (no. 9), pp. 2609-2619, 2018.

[3] Akkerman Q.A. et al., Nature Energy, vol. 2, (no. 2), 2017.

[4] D'Innocenzo V. et al., Nature Communications, vol. 5, 2014.

[5] Stranks S.D. et al., Science, vol. 342, (no. 6156), pp. 341-344, 2013.

ADVANCED MATERIALS FOR SUSTAINABLE FUTURE TECHNOLOGIES



Principal Investigator
Fabrizio Pirri
CSFT@PoliTo

Description

The unit is focused on new materials, new technologies, devices and systems for low-carbon economy, energy transition, and sustainability. The attention is CO2 capture and valorization; H2 production, storage and use; energy storage and management; and waste valorization. New nanocatalysts, electrolytes, electrodes, membranes are synthesized and characterized at the nanoscale. The materials are tested in new generation devices.

In addition, technically feasible and economically affordable biotechnological processes based on cyanobacteria, green algae, anaerobic archaea, methanogens, acetogens for value-added compounds are investigated. The exploitation of particular metabolic feature allows the development of innovative biotechnological reactors to convert polluting greenhouse gases (e.g. CO_2) and wastes into bulk and fine chemicals of manifold industrial interests as well as green fuels.

Achievements

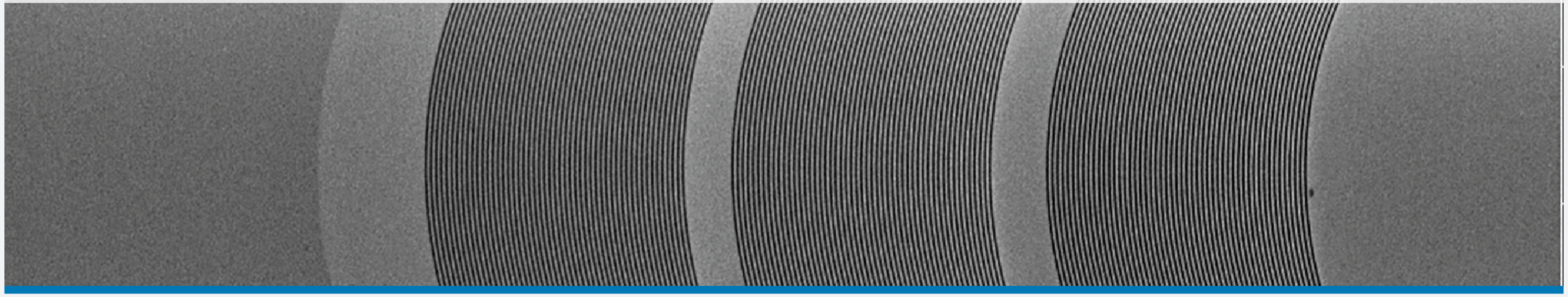
The main achievements of the unit were the realization of large-scale labs to synthesize and characterize materials, and to assemble and test fuel cells, batteries, supercapacitors, engines or combustion systems, waste valorization reactors, electrocatalytic reactors and bioreactors.

Thanks to PNRR funding (2023-2026), it was possible to implement new manufacturing technologies at high-technology readiness level with reduced environmental and energy impact, and increased recyclability and durability of materials.

Representative Publications

[1] Roppolo I. et al., Advanced Materials, 2023.
[2] Lettieri S. et al., Journal of Energy Chemistry, vol. 67, pp. 500-507, 2022.
[3] Sassone D. et al., Applied Energy, vol. 324, 2022.
[4] Baudino L. et al., Advanced Science, vol. 9, (no. 27), 2022.
[5] Lourenco M.A.O. et al., Chemical Engineering Journal, vol. 414, 2021.

MULTIFUNCTIONAL NEURAL INTERFACES WITH DEEP-BRAIN REGIONS



Principal Investigator
Ferruccio Pisanello
CBN@UniLe

Description

We seek to develop new paradigms to interface with the central nervous system. We do this by exploiting physical phenomena in unconventional ways to realize a new generation of devices that are able to gather multifunctional signals from the brain and to control its physiology.

Our focus is:

i. Basic technology research that explores the possibility of using light-matter interactions to interface with brain tissue in order to generate a new class of all-optical multifunctional neural endoscopes;
ii. Designing and manufacturing implantable photonic devices with the goal of simultaneously monitoring and controlling brain physiology with spatial selectivity and high signal-to-noise ratio; and
iii. Devising systems with high technology readiness level for medical applications, such as improving brain tumor resection surgery.

Achievements

We have described the integration of multiple functionalities in low-invasiveness neural implants. We have patented and published in several international high-impact peer-reviewed Journals (Nat Methods, Nat Mater, Nat Neurosci, Adv Mater).

We have secured high-risk high-gain competitive grants (ERC Starting, ERC Proof-of-Concept). We coordinate an EU Fet-Open project to introduce nanophotonics into the brain, and we participate in an EU-wide consortium to develop methods to optically access deep brain regions.

Representative Publications

[1] Zheng D. et al., Advanced Materials, vol. 35, 2023.
[2] Collard L. et al., Small, 2022.
[3] Spagnolo B. et al., Nature Materials, 2022.
[4] Pisano F. et al., Nature Methods, 2019.
[5] Pisanello F. et al., Nature Neuroscience, vol. 20, (no. 8), pp. 1180-1188, 2017.

APPLIED ENERGY MATERIALS AND TECHNOLOGIES

Principal Investigator
Isabella Poli
CSFT@PoliTo

Description

Scaling clean energy requires new materials that can help boost the amount of renewables we harvest and can store surpluses when they are needed. In the Applied Energy Materials and Technologies group, we focus on the synthesis and processing of new materials, including solar energy materials and photoelectrode architectures for photoelectrochemical and photocatalytic reactions, such as water splitting, carbon dioxide reduction and photodegradation of organic pollutants.

We have experience in materials science, develop new materials and characterize them extensively to relate their properties to their final performance, thus increasing the fundamental understanding needed to optimize them.

Achievements

The Applied Energy Materials and Technologies Research Unit will kick off in March 2024. Together with the other Research Units of the Center for Sustainable Future Technologies, we aim to transfer new basic knowledge into new applications and technologies to enable a sustainable energy transition.

Representative Publications

[1] Martani S. et al., ACS Energy Letters, vol. 8, (no. 6), pp. 2801-2808, 2023.
[2] Berger F.J. et al., ACS Energy Letters, pp. 3876-3882, 2023.
[3] Treglia A. et al., Materials Horizons, vol. 9, (no. 6), pp. 1763-1773, 2022.
[4] Zhou Y. et al., Nature Reviews Materials, vol. 6, (no. 11), pp. 986-1002, 2021.
[5] Poli I. et al., ACS Energy Letters, pp. 609-611, 2021.

NANOBIOINTERACTIONS & NANODIAGNOSTICS

Principal Investigator
Pier Paolo Pompa
CCT@Morego

Description

Our mission is to develop smart nanobiosensors for on-field and point-of-care (POC) diagnostics. Our technology is based on hybrid detection strategies that exploit the combination of plasmonic nanoparticles or nanozymes, molecular biology, biotechnology, and AI. We focus on instrument-free portable assays that amplify isothermal/room-temperature signals or targets, and provide naked-eye or smartphone-based colorimetric readouts (powered by AI algorithms). We develop both in-solution and LFD-like devices with multiplexing capabilities. Our research applications include food safety and traceability, anticounterfeiting, in vitro diagnostics for healthcare and wellness, and environmental controls. We have a strong technology transfer focus and have established numerous partnerships with industry, several licensed technologies, and one start-up.

Achievements

Our group has achieved several important results in POC diagnostics, with different patents and technologies translated into industrial products.

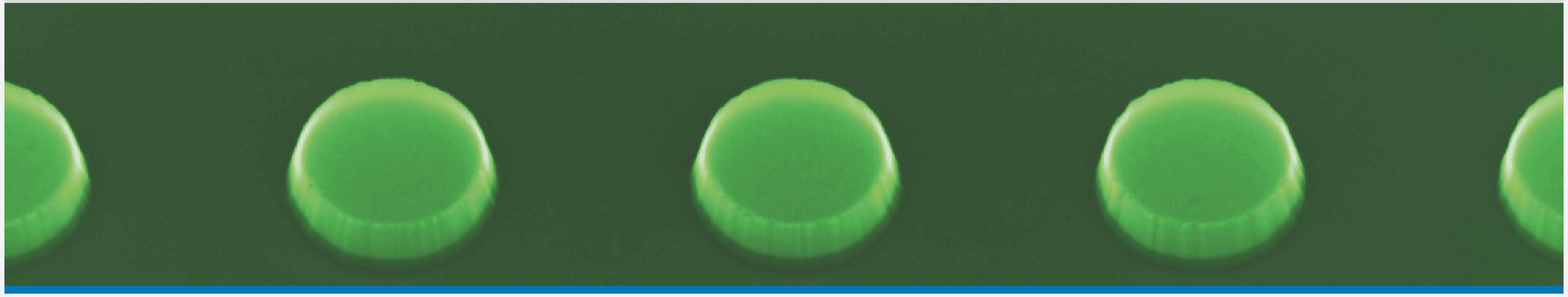
Examples include:

i. NanoTracer, one of the first portable tests worldwide for genetic traceability of food);
ii. iBlue, a Pt nanozyme-based colorimetric sensor for POC detection of oxidative stress;
iii. A colorimetric nanoplasmonic device to monitor hyperglycemia in saliva;
iv. A dual catalytic/plasmonic nanosensor for naked-eye detection of Hg trace contaminations; and
v. A fast isothermal molecular test for detecting Covid-19 in saliva.

Representative Publications

[1] Tarricone G. et al., Nano Letters, 2023.
[2] Pedone D. et al., Analytical Chemistry, vol. 92, (no. 13), pp. 8660-8664, 2020.
[3] Donati P. et al., Angewandte Chemie - International Edition, vol. 58, (no. 30), pp. 10285-10289, 2019.
[4] Valentini P. et al., Angewandte Chemie - International Edition, vol. 56, (no. 28), pp. 8094-8098, 2017.
[5] Pedone D. et al., Chemical Society Reviews, vol. 46, (no. 16), pp. 4951-4975, 2017.

NANOPHOTONIC DEVICES



Principal Investigator
Michele Tamagnone
CCT@Morego

Description

In today's information revolution, optical and optoelectronic devices bridge the gap between digital electronics and optical fiber telecommunications. However, the world needs new miniaturized optoelectronic technologies based on new nanophotonic devices and with integration on silicon.

Established in April 2021, we study new nanophotonic devices for optoelectronics and sensing applications. We focus on novel 2D materials and their applications for light modulation and wavefront manipulation. In particular, we study the miniaturization of nanostructures made in the cleanroom at IIT. With our top-down approach, we have created structures of just 5 nm in size. We aim to use these new structures to control the band structure and quantum confinement in 2D materials for future optoelectronic devices.

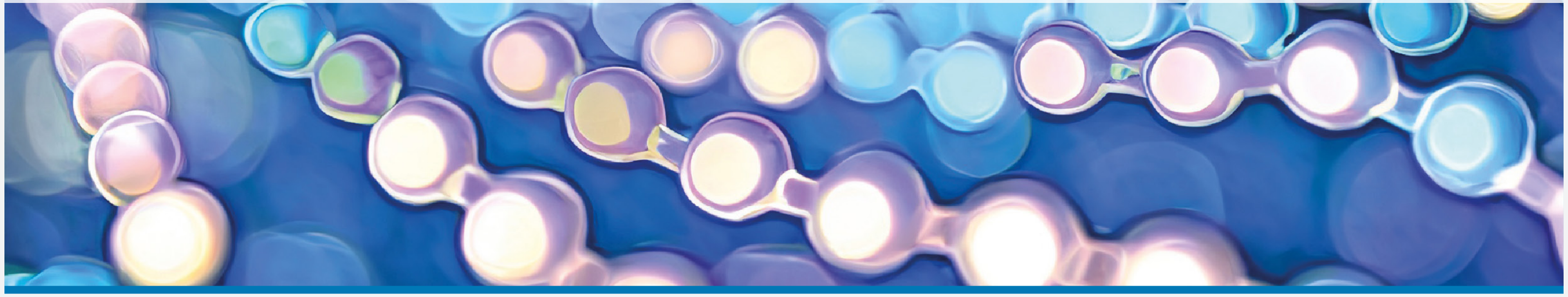
Achievements

i. We secured an ERC Starting grant for the project: Sub-nanometer quantum engineering of 2D materials for optoelectronic devices – PI);
ii. We secured ASI funding for the project SNAPS: Scintillatori con NAnocristalli di Perovskite per applicazioni Spaziali, co-PI (PI: Giorgio Divitini);
iii. We used a top-down approach to make nanometer and subnanometer structures for nanophotonic applications;
iv. We observed bound states in the continuum in a polaritonic system; and
v. We realized speckle-free holograms with a new theoretical method.

Representative Publications

[1] Spaegele C.M. et al., Science advances, vol. 9, (no. 24), 2023.
[2] Dorrah A.H. et al., Nanophotonics, vol. 11, (no. 4), pp. 713-725, 2022.
[3] Spaegele C. et al., Reviews of Electromagnetics, 2022.
[4] Spagele C. et al., Nature Communications, vol. 12, (no. 1), 2021.
[5] Dorrah A.H. et al., Nature Communications, vol. 12, (no. 1), 2021.

POLYMERS AND BIOMATERIALS



Principal Investigator
Nicola Tirelli
CCT@Morego

Description

Our research areas include polymer synthesis, colloidal characterization, and drug delivery.

In particular, we work on:

i. Oxidation-responsive materials. In biology, oxidants (Reactive Oxygen Species, ROS) can induce survival, activation, inflammation, aging, tumorigenesis, or direct cell death, depending on their concentration. We develop soluble macromolecules, micelles, and nanoparticles based on sulfur(II)-containing structures. These act as ROS scavengers and so have selective anti-inflammatory or antifibrotic properties; and
ii. Nanomaterials based on hyaluronic acid (HA), which is a natural polysaccharide. We use HA's interactions to provide (tumor)-targeting features to pharmaceutical (nano)formulations. We focus on mechanistically understanding the interactions between HA and the cellular receptors with which it interacts.

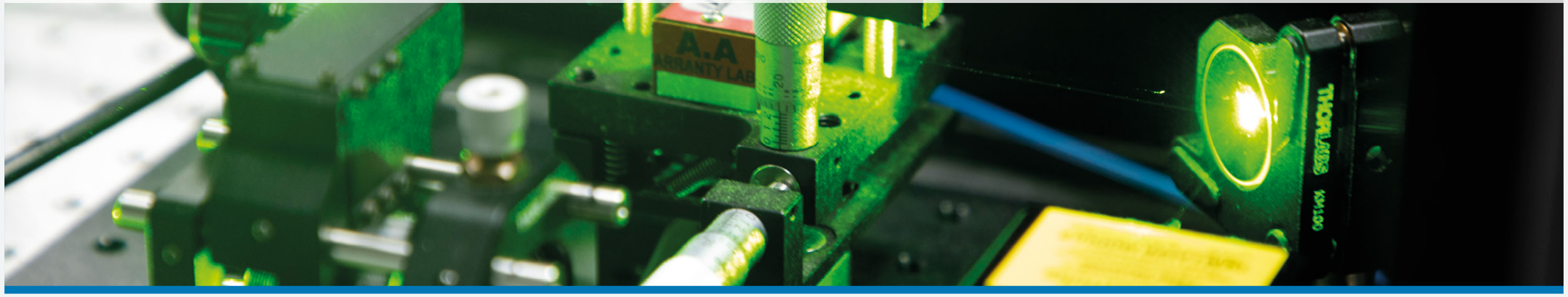
Achievements

In our 2022 paper in J Am Chem Soc (DOI: 10.1021/jacs.2c09232) , we demonstrated the concept of "stealth" active polymers (and bioconjugates). These macromolecules are mostly "invisible" to the immune system, but can nevertheless perform biologically important actions. In this case, we reported a polymer covalently linked to proteins, which protects them from immune clearance (masking them from antibodies) and from oxidative damage (being oxidized in their stead).

Representative Publications

[1] Siani A. et al., Biomaterials Advances, vol. 153, 2023.
[2] D'Arcy R. et al., Journal of the American Chemical Society, vol. 144, (no. 46), pp. 21304-21317, 2022.
[3] Scoponi G. et al., Macromolecules, 2021.
[4] El Mohtadi F. et al., Biomacromolecules, vol. 21, (no. 2), pp. 305-318, 2020.
[5] Gennari A. et al., Tetrahedron, vol. 76, (no. 47), 2020.

MOLECULAR MICROSCOPY AND SPECTROSCOPY



Principal Investigator
Giuseppe Vicidomini
CHT@Erzelli

Description

Optical microscopy is one of the least invasive methods for visualizing biological structures and functions within living cells and organisms at almost molecular scale. Yet it is still a challenge to use conventional optical microscopy to understand many fundamental biological processes relevant to health and disease. Our mission is to design and develop state-of-the-art microscopy and analytical tools, empowering biologists to delve into living systems with unprecedented spatiotemporal resolutions and ranges, while minimizing invasiveness and enhancing information content.

Our projects seamlessly integrate cutting-edge photonics technologies, labeling protocols, optical architectures, spectroscopy techniques, and machine learning approaches. While our focus is technological advancement, we also actively collaborate with biologists to rigorously test and refine our tools, ensuring they facilitate new biological insights.

Achievements

Quantum tech is reshaping photonics research. Our group has pioneered the innovative approach of single-photon microscopy. By integrating single-photon avalanche diode array detectors into fluorescent laser-scanning microscopy (LSM), we can capture fluorescence photon by photon.

This enhances our ability to extract valuable information from samples. For example, we introduced super-resolved fluorescence lifetime imaging and fluorescence lifetime fluctuation spectroscopy, enabling new studies of biomolecular processes in living cells. The single-photon LSM revolution is just beginning.

Representative Publications

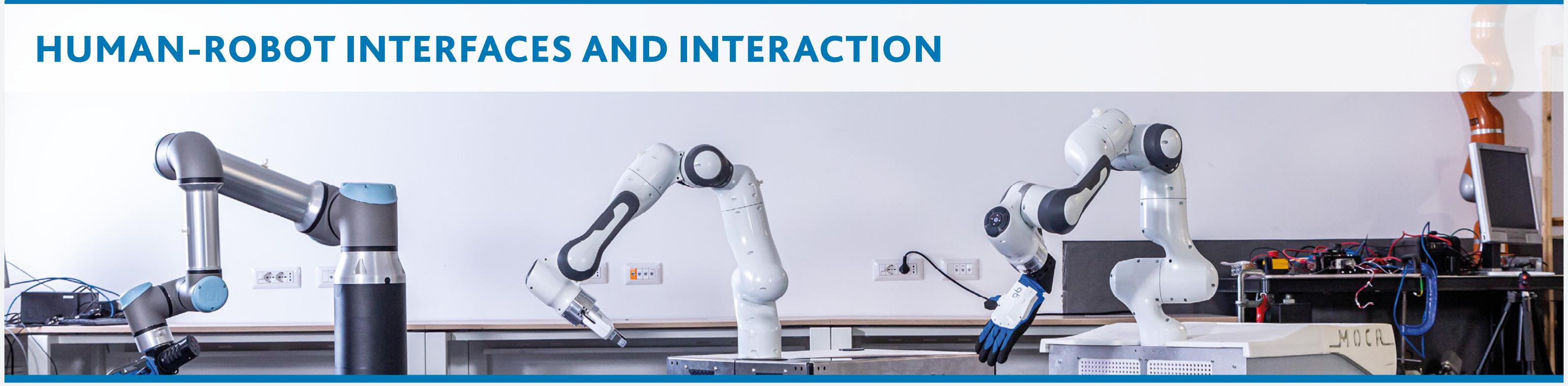
[1] Zunino A. et al., Nature Photonics, vol. 17, (no. 6), pp. 457-458, 2023.
[2] Tortarolo G. et al., Nature Communications, vol. 13, (no. 1), 2022.
[3] Rossetta A. et al., Nature Communications, vol. 13, (no. 1), 2022.
[4] Slenders E. et al., Light: Science and Applications, vol. 10, (no. 1), 2021.
[5] Castello M. et al., Nature Methods, vol. 16, (no. 2), pp. 175-178, 2019.

RD: Robotics

Research Units

Principal Investigators

HUMAN-ROBOT INTERFACES AND INTERACTION



Principal Investigator
Arash Ajoudani
CRIS@SanQuirico

Description

We develop intelligent robots that can enable timely, natural, and human-in-command interactions with humans on both cognitive and physical levels, representing the concept of socio-physical interaction. Our multidisciplinary approach spans the theoretical, technical, and practical dimensions of modern collaborative systems.

On the one side, we develop interaction-autonomous systems that can (re)plan on the fly by relying on multimodal perception. Here, we develop hybrid learning and optimization frameworks for mobile and fixed-base collaborative robots and wearable assistive devices to boost their interaction autonomy. On the other side, we develop cutting edge cognitive and physical models to anticipate human ergonomics and socio-physical states. The development of Intelligent interfaces with multimodal processing capabilities is also linked to our strategic vision and aim of creating timely and comforting (ergonomic) robot actions in response to humans and tasks.

Achievements

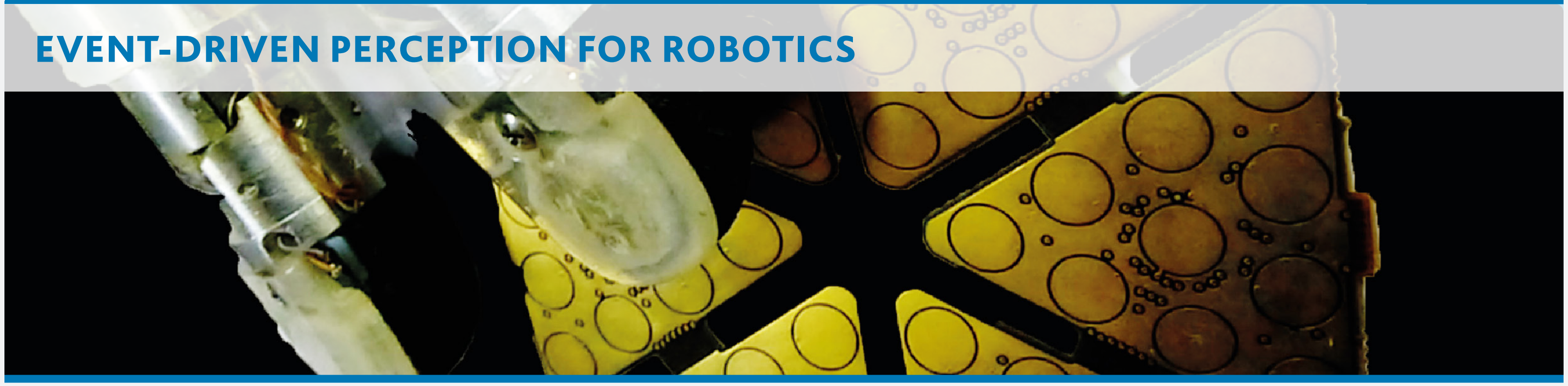
We host two ERC grants (StG Ergo-Lean; PoC Real-Move). Our PI is Coordinator of the H2020 SOPHIA project, Co-coordinator of the H2020 CONCERT project, and a PI of the H-MSCA project RAICAM and three national grants. He also coordinates the R4M lab at the Leonardo labs, and is a PI of the IIT-Intellimech JOiiNT lab.

The lab has been honored with more than 25 prestigious awards including the IEEE-RAS Early Career Award, KUKA Innovation Award, Amazon Research Award, Georges Giralt PhD Award, IEEE I-RAS best PhD Award, and several best paper awards.

Representative Publications

[1] Lagomarsino M. et al., IEEE Robotics and Automation Letters, vol. 8, (no. 8), pp. 4378-4385, 2023.
[2] Zhao J. et al., IEEE Robotics and Automation Letters, vol. 7, (no. 3), pp. 8036-8043, 2022.
[3] Lagomarsino M. et al., Robotics and Computer-Integrated Manufacturing, vol. 78, 2022.
[4] Lorenzini M. et al., IEEE Transactions on Human-Machine Systems, vol. 52, (no. 5), pp. 812-823, 2022.
[5] Kim W. et al., Proceedings - IEEE International Conference on Robotics and Automation, pp. 10191-10197, 2020.

EVENT-DRIVEN PERCEPTION FOR ROBOTICS



Principal Investigator
Chiara Bartolozzi
CRIS@SanQuirico

Description

We develop neuromorphic technology to improve the autonomy of robotic platforms. We seek to understand the principles of neural computation and sensing in order to develop artificial perception devices and algorithms for deployment in artificial behaving systems. Our goal is to equip robots and rehabilitative and prosthetic devices with neuromorphic perceptive and decisional systems that can better cope with unconstrained, noisy, and often ambiguous inputs in order to extract information that is relevant for behavior. The result will be artificial intelligent systems that become progressively more autonomous and able to act in the real world and seamlessly integrate with humans.

Achievements

We have:

i. Developed the unique neuromorphic iCub platform, equipped with event-driven vision, tactile, and auditory sensors, neuromorphic computing platforms, and perception algorithms.
ii. Prototyped neuromorphic circuits for tactile perception based on piezoelectric, resistive, and capacitive transducers.
iii. Developed principled methods to compute with the stream of events from dynamic vision sensors, leveraging from neuroscience, spiking neural networks, computer vision, and machine learning.

We are developing high-speed applications for robots that seamlessly interact with the real world.

Representative Publications

[1] Bartolozzi C. et al., Nature Communications, vol. 13, (no. 1), 2022.
[2] Ghosh S. et al., Scientific Reports, vol. 12, (no. 1), 2022.
[3] Janotte E. et al., 20th IEEE International Interregional NEWCAS Conference, NEWCAS 2022 - Proceedings, pp. 119-123, 2022.
[4] Glover A. et al., IEEE Transactions on Pattern Analysis and Machine Intelligence, 2021.

SOFT BIOROBOTICS PERCEPTION

Principal Investigator
Lucia Beccai
CCT@Morego

Description

We investigate soft and embodied sensing processes in versatile soft robotic platforms that can interact with and assist humans. Going beyond vision to focus on touch, we study the link between material properties, morphology, movement, and environment to develop adaptive sensing in soft grasping and manipulation. Here we can also adopt bioinspired strategies. For example, we study the amazing elephant trunk to derive new design principles for soft yet strong continuum manipulators capable of merging in different environments.

Which body structure, sensing, and actuation strategies will create the intelligent physical interaction necessary to coordinate morphology and behavioral control? We target jointless integrated systems based on 3D transduction and actuation technologies developed by tuning materials, structures, transducers, electronics, and processing. Our goal is to achieve soft multidimensional movement for reliable, deformable systems that can be guided by active touch. Our targeted applications serve the industrial, assistive, and search and rescue fields.

Achievements

We have demonstrated various soft tactile sensing methods. These include all-optical multitouch tactile skins and highly stretchable strain-selective sensors, and inductive flexible sensors for the sensing of pressure, vibration, angle, and curvature.

Starting from ultra-light vacuum-based artificial muscles, we pioneered a new method for programmed multidimensional actuation by monolithic architected structures. In our new research area on elephant-trunk-inspired robotics, we started studying prehensile abilities by quantifying the large animal's interaction with instrumented objects and safe protocols, and we shed light on the skin's microstructure.

Representative Publications

[1] Joe S. et al., Advanced Science, 2023.
[2] Lo Preti M. et al., iScience, vol. 26, (no. 9), 2023.
[3] Lo Preti M. et al., IEEE/ASME Transactions on Mechatronics, 2022.
[4] Wang H. et al., Advanced Materials Technologies, vol. 5, (no. 11), 2020.
[5] Wang H. et al., Advanced Science, vol. 5, (no. 9), 2018.

SOFT ROBOTICS FOR HUMAN COOPERATION AND REHABILITATION

Principal Investigator
Antonio Bicchi
CRIS@SanQuirico

Description

Our philosophy is to improve the technology of artificial systems by improving our understanding of natural systems.

Our early work contributed to the birth of collaborative robotics. Today, we capitalize on this with an effective technology transfer to industry via the JOiiNT Lab and by creating spinoff companies (qbrobotics, RPWC, and others currently being founded).

Our vision is to go beyond the paradigm of human-robot cooperation in order to address the new frontier of human-robot integration. We believe that the technology of soft robotics, together with the neuroscientifically inspired architecture of our robots, can produce revolutionary prostheses, rehabilitation procedures, and immersive and intuitive interfaces to control complex machines, which then become extensions of human abilities. The ultimate goal is to make robots usable by, and useful to, everybody in our society.

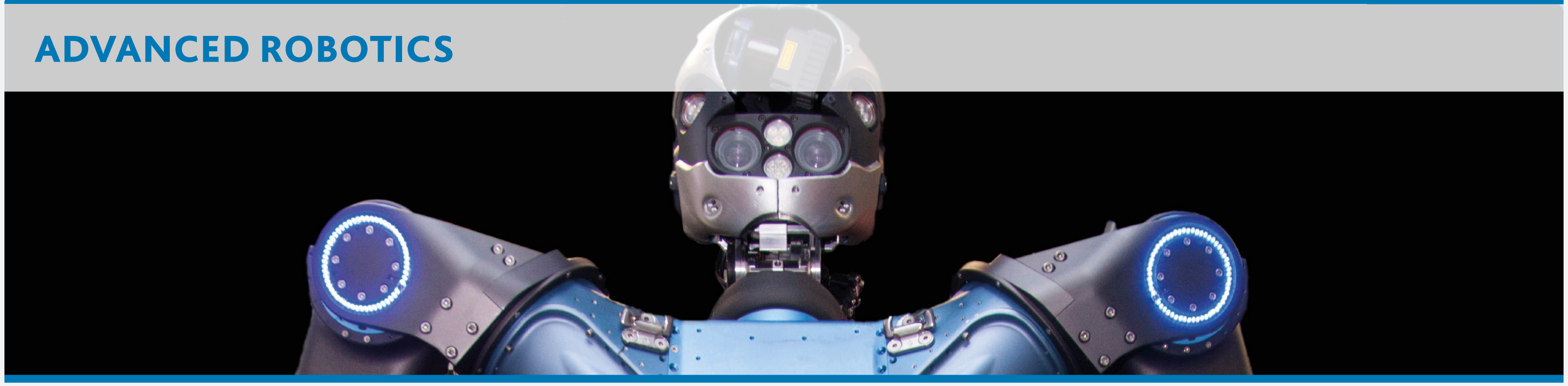
Achievements

We have received 5 ERC grants. Our PI is Editor-in-Chief (EiC) of IJRR, was Founding EiC of IEEE RA-L, and President of I-RIM. Five of our students have been finalists of the G. Giralt Award for Best PhD thesis in Robotics, with 3 of them being winners (Catalano, Della Santina, Averta). Altobelli and Barontini won EuroHaptics Best PhD Thesis award. Barontini also won the SIDRA Award for best PhD thesis in Italy. Pagnanelli and Capsi won the ABB-IEEE awards for best MS and PhD Thesis in Italy, respectively. Ajoudani (2021) and Della Santina (2023) won the internationally prestigious IEEE RAS Early Career Award.

Representative Publications

[1] Mengacci R. et al., International Journal of Robotics Research, vol. 40, (no. 1), pp. 348-374, 2021.
[2] Averta G. et al., Journal of NeuroEngineering and Rehabilitation, vol. 17, (no. 1), 2020.
[3] Laghi M. et al., International Journal of Robotics Research, vol. 39, (no. 4), pp. 514-539, 2020.
[4] Rossi M. et al., IEEE Transactions on Biomedical Engineering, vol. 66, (no. 1), pp. 138-149, 2019.
[5] Santina C.D. et al., IEEE Robotics and Automation Letters, vol. 4, (no. 2), pp. 1533-1540, 2019.

ADVANCED ROBOTICS



Principal Investigator
Darwin Caldwell
CRIS@SanQuirico

Description

Established in 2006 as one of IIT's founding departments, Advanced Robotics (ADVR) takes an innovative, multidisciplinary approach to controlling and designing robots, and developing novel robotic components and technologies. This includes both hard systems (mechanical/electrical design and fabrication, sensors, actuators) and soft systems (control, software, human factors). We have developed many internationally recognized robots such as cCub, COMAN, WalkMan, HyQ and PHOLUS/Centauro, and HyQ2Max. Our current priorities are:

i. Biomedical Robotics Lab (BRL). Novel technologies to augment human capabilities in challenging medical environments (e.g. CALM, SVEI, CathBot, CathBot Pro);
ii. XoLab. Exoskeletons and wearable devices to reduce/prevent musculoskeletal disorders (e.g. XoTrunk, Xoshoulder, XoElbow, XoSoft);
iii. RAIN Lab. Industry-focused research on robotic automation and inspection (e.g. ILDIR); and
iv. Mixed Reality & Telepresence.

Achievements

Notable awards include the 2022 Compasso d'Oro for the XoSoft exoskeleton, the 2018 Athanasiou ABME Award, best paper at HFR 2020, CRAS 2020, IEEE CBS 2019, CLAWAR 2019, 9th CRAS, and CRAS 2018, runner-up at ICARM 2021, CoRL 2019, and ISMR 2018, best student paper winner at IEEE-CYBER 2021, and runner-up at ICARCV 2018. We were also successful in several competitions and demonstrations including IEEE/RSJ IROS 2018 and WeRob 2018.

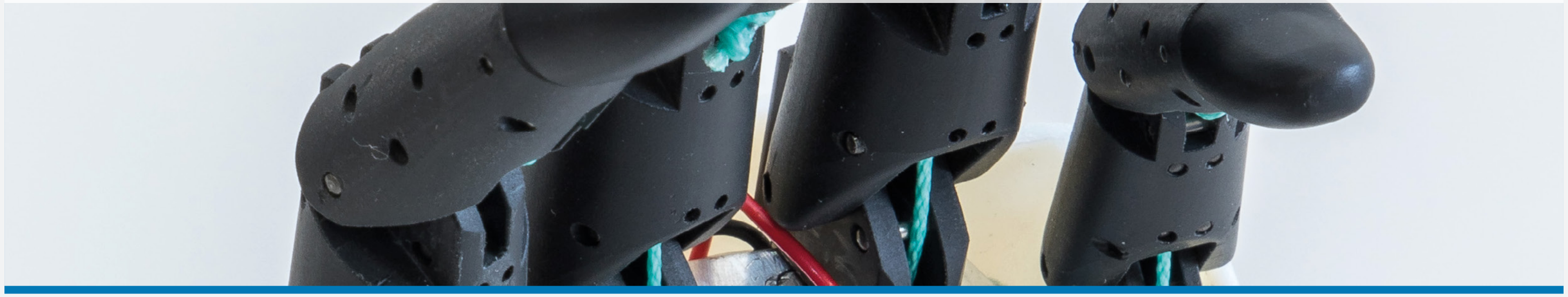
The start-up Proteso arose from XoLab's work. BRL performed the world's first 5G telesurgery.

Developing Joint Labs has also been a cornerstone of ADVR activities.

Representative Publications

[1] Tsagarakis N.G. et al., Journal of Field Robotics, vol. 34, (no. 7), pp. 1225-1259, 2017.
[2] Rozo L. et al., IEEE Transactions on Robotics, vol. 32, (no. 3), pp. 513-527, 2016.
[3] Semini C. et al., International Journal of Robotics Research, vol. 34, (no. 7), pp. 1003-1020, 2015.
[4] Jafari A. et al., IEEE/ASME Transactions on Mechatronics, vol. 18, (no. 1), pp. 355-365, 2013.
[5] Saglia J.A. et al., IEEE/ASME Transactions on Mechatronics, vol. 18, (no. 6), pp. 1799-1808, 2013.

REHAB TECHNOLOGIES - INAIL-IIT LAB



Principal Investigator
Matteo Laffranchi
CCT@Morego

Description

We research novel yet sustainable assistive and rehabilitative solutions for people with neuromotor impairments. The ultimate goal is to develop the next generation of hi-tech medical devices by combining our robotics expertise with patient needs and clinician expertise. Our human-centered design process puts patients at the heart of our research. We investigate the patient's physiological, motor, and cognitive-behavioral processes in order to design personalized neurorehabilitation interventions that promote neuroplasticity by using robotic devices to replace and retrain motor functions.

Rehab Technologies is ISO 13485-certified (QMS for medical devices) and follows international standards in designing its devices, including IEC 62366 on the usability of medical devices and IEC 60601 on their safety.

Achievements

We have developed several technologies with high technology readiness levels, and brought them to clinical trials on patients. These are: Hannes (bionic hand), Twin (lower limb exoskeleton), Float (upper limb exoskeleton), Hybrid Knee and Smart Ankle (bionic leg).

We also develop novel and objective electrophysiological measurements or biomarkers and strategies to provide assist-as-needed rehab protocols.

From 2022-2023, we obtained ± EUR 11 M for research and industrial projects, published 16 journal articles and 13 conference articles, and filed 15 patent applications covering new inventions.

Representative Publications

[1] Marinelli A. et al., IEEE Transactions on Biomedical Engineering, 2023.
[2] Buccelli S. et al., Applied Sciences (Switzerland), vol. 12, (no. 7), 2022.
[3] Semprini M. et al., Frontiers in Neuroscience, vol. 16, 2022.
[4] Chiappalone M. et al., Science Robotics, vol. 7, (no. 64), 2022.
[5] Barresi G. et al., Frontiers in Neurorobotics, vol. 15, 2021.

BIOINSPIRED SOFT ROBOTICS

Principal Investigator
Barbara Mazzolai
CCT@Morego

Description

We specialize in developing soft robots inspired by nature, particularly plants and soft animals. These bioinspired robots are designed to operate in extreme and unstructured environments, with a focus on soft multifunctional materials, perception-based behaviors, embodied energy, and distributed control. Our robots exhibit advanced capabilities in mobility (e.g. stretching, climbing, growing, morphing), grasping, manipulation, and safe interactions. These technologies find applications in various fields, including natural environment exploration, infrastructure monitoring, archaeology, precision agriculture, and marine operations.

Our vision is to create sustainable, lifelike machines (EcoRobots) that seamlessly integrate into natural ecosystems while performing various tasks in dynamic conditions. Additionally, we aim to use these bioinspired robots for reverse biology, as experimental tools to investigate biological behaviors.

Achievements

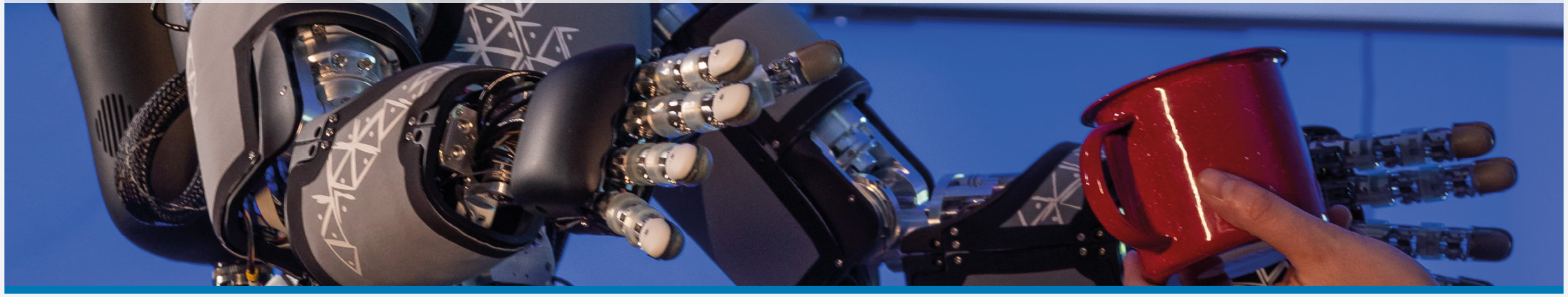
I pioneered the use of plants as models in robotics, leading to the creation of the first robot inspired by plant roots (the Plantoid), and the first robots inspired by climbing plants (GrowBots). Our research includes developing plant-seed-inspired biodegradable soft robots for environmental monitoring (I-Seeds), and exploring plant-fungus communication to develop new models of networks in Robotics and AI (I-Wood ERC).

On the animal-inspired side, we develop soft technologies, such as octopus-like arms with sensorized suckers, elephant-trunk-inspired muscles, and earthworm-like robots.

Representative Publications

[1] Cecchini L. et al., Advanced Science, 2023.
[2] Del Dottore E. et al., Science Robotics, 2023.
[3] De Pascali C. et al., Science Robotics, vol. 7, (no. 68), 2022.
[4] Meder F. et al., Energy and Environmental Sciences, vol. 15, (no. 6), pp. 2545-2556, 2022.
[5] Must I. et al., Nature Communications, vol. 10, (no. 1), 2019.

HUMANOID SENSING AND PERCEPTION



Principal Investigator
Lorenzo Natale
CRIS@SanQuirico

Description

We study algorithms that allow humanoid robots to perceive and explore the environment by manipulating objects and interacting with humans. Motivated by research on human perception, our strategy seeks to explore active perception and multimodal integration, whereby the robot actively explores the environment to improve perception and learning, leveraging various sensory modalities.

We perform a mix of basic and applied research in domains including rehabilitation, human-robot collaboration, service robotics, and industrial robotics. We also seek to extend robot autonomy by developing software tools for distributed computing, and methodologies for modelling and deploying robot behaviors. In our work, we use the humanoid robots iCub, R1, and ergoCub.

Achievements

We helped develop the humanoid robots iCub, R1, and ergoCub, and have run several projects (EU and industrial projects), securing funding of more than EUR 6 M. Our lab has advanced the state of the art in robot perception (e.g. object recognition, segmentation, pose estimation), object manipulation, distributed computing across wired and wireless networks, and software methodologies for orchestrating components with behavior trees.

Representative Publications

[1] Bottarel F. et al., IEEE Robotics and Automation Magazine, 2023.
[2] Colledanchise M. et al., IEEE Transactions on Robotics, vol. 38, (no. 4), pp. 2557-2576, 2022.
[3] Ceola F. et al., IEEE Transactions on Robotics, vol. 38, (no. 5), pp. 3154-3172, 2022.
[4] Colledanchise M. et al., IEEE Robotics and Automation Letters, vol. 6, (no. 3), pp. 5929-5936, 2021.
[5] Piga N. et al., IEEE Robotics and Automation Letters, 2021.

ARTIFICIAL AND MECHANICAL INTELLIGENCE

Principal Investigator
Daniele Pucci
CRIS@SanQuirico

Description

We combine control theory, machine learning, and mechanics to devise and control the next generation of humanoid robots.

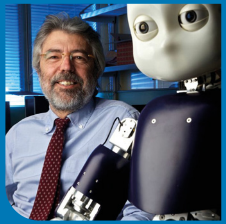
Achievements

i. Working with the iCub Tech Facility, we have created co-design tools to develop the ergoCub robot (https://ergocub.eu);
ii. We work on control and machine learning so that humanoid robots can interact with humans and move in human-like environments;
iii. We are developing the first flying jet-powered humanoid robot iRonCub from design to control (https://ami.iit.it/aerial-humanoid-robotics); and
iv. We are developing wearable devices and AI algorithms for human being health indicators (https://ifeeltech.eu).

Representative Publications

[1] Rapetti L. et al., Proceedings - IEEE International Conference on Robotics and Automation, vol. 2023-May, pp. 7504-7510, 2023.
[2] Viceconte P.M. et al., IEEE Robotics and Automation Letters, vol. 7, (no. 2), pp. 2779-2786, 2022.
[3] Dafarra S. et al., IEEE Transactions on Robotics, vol. 38, (no. 6), pp. 3414-3433, 2022.
[4] Dafarra S. et al., arXiv, 2022.
[5] Romualdi G. et al., Proceedings - IEEE International Conference on Robotics and Automation, pp. 10412-10419, 2022.

ROBOTICS BRAIN AND COGNITIVE SCIENCES



Principal Investigator
Giulio Sandini
CHT@Erzelli

Description

The latest version of a founding department of IIT, Robotics Brain and Cognitive Sciences (RBCS) studies human-robot interactions, focusing on the cognitive aspects of multisensory integration and social interaction. RBCS collaborates with other units, particularly the CONTACT and UVIP units led by A. Sciutti and M. Gori.

Using the iCub humanoid robot, we study humans' cognitive abilities and build robots that interact with humans in a humane, friendly, and intuitive way. To move beyond nonconverging incremental approaches, RBCS has proposed an open initiative (https://icog.eu) to study and implement a cognitive architecture to guide activities. This baseline will allow convergent cumulative progress in the development of an operational model of cognition.

Achievements

As one of IIT's founding departments, RBCS embodies IIT's goal of multidisciplinarity and science-based technological development. Our approach follows the streamlining of the RobotCub-iCub EU project coordinated by Giulio Sandini at Genoa University's LIRA Lab since 2004.

Thanks to our professional growth and by implementing experimental infrastructures and facilities, RBCS has contributed to IIT's growth in the past 20 years by sprouting into new research units and facilities that represent one of IIT's science and technology pillars.

Representative Publications

[1] Sciutti A. et al., IEEE Robotics & Automation Magazine, 2023.
[2] Leo F. et al., IEEE Transactions on Haptics, vol. 15, (no. 2), pp. 339-350, 2022.
[3] Escobar M.-J. et al., IEEE Transactions on Cognitive and Developmental Systems, vol. 14, (no. 2), pp. 255-257, 2022.
[4] Wang Y. et al., Scientific Reports, vol. 11, (no. 1), 2021.

COGNITIVE ARCHITECTURE FOR COLLABORATIVE TECHNOLOGIES

Principal Investigator
Alessandra Sciutti
CHT@Erzelli

Description

We aim to enable robots to understand and predict human intentions, internal states, and limitations while being transparent, predictable, and adaptable in their own behaviors. To achieve this, we investigate the sensory, motor, and cognitive bases of human social abilities by using robots as ideal controllable probes to test and model the dynamics of human interaction.

We then study how to integrate these abilities into a cognitive architecture, relying on memory, motivation, and anticipation to support social awareness, adaptability, and autonomous learning. Our constructive and embodied approach thus contributes to a more profound understanding of human cognition. To achieve our technological goal of developing more intuitive and adaptable robots, our multidisciplinary team has expertise in robotics, machine learning, neurophysiology, psychology, and philosophy.

Achievements

We design computational models of shared perception and study the impact of asymmetries in perception on trust toward the robot (ERC Starting Grant project wHiSPER 804388).

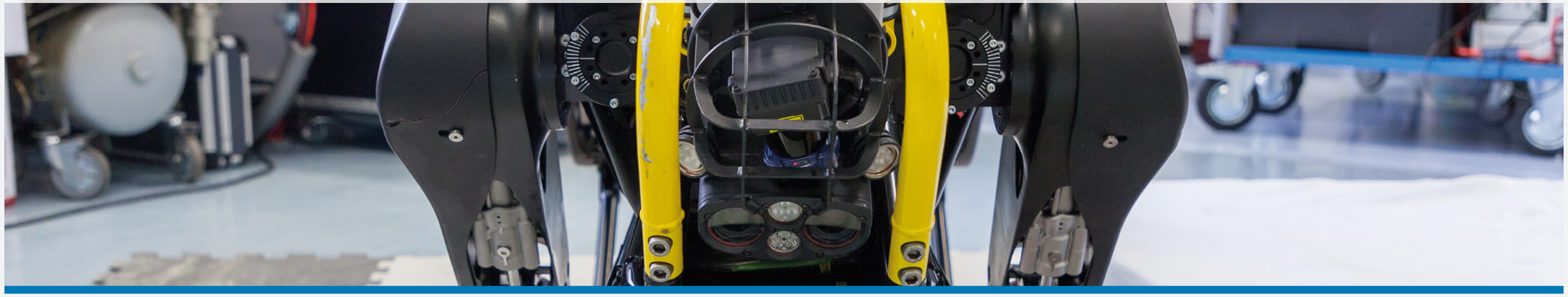
We develop:
i. Robots' understanding of humans' nonverbal cues in order to infer their partner's intentions and internal states.
ii. Frameworks of human-robot interaction to support adaptation in real time and over the long term.

We leverage model-based and machine-learning-based approaches to develop understandable robot behaviors. We aim to develop a cognitive architecture, focusing on the affective and social components of cognition.

Representative Publications

[1] Barros P. et al., IEEE Access, vol. 10, pp. 103932-103947, 2022.
[2] Leo F. et al., IEEE Transactions on Haptics, vol. 15, (no. 2), pp. 339-350, 2022.
[3] Aroyo A.M. et al., IEEE Robotics and Automation Letters, vol. 6, (no. 3), pp. 5681-5688, 2021.
[4] Di Cesare G. et al., Proceedings of the National Academy of Sciences of the United States of America, vol. 118, (no. 44), 2021.
[5] Zonca J. et al., iScience, vol. 24, (no. 12), 2021.

DYNAMIC LEGGED SYSTEMS



Principal Investigator
Claudio Semini
CRIS@SanQuirico

Description

We seek to design and control aspects of agile legged robots. Our focus is quadruped robots for challenging environments and heavy-duty tasks. We are interested in using optimization, machine learning, and perception to increase the locomotion performance and manipulation abilities of legged robots. We design next-generation quadrupeds with energy-efficient actuation, smart materials, and intelligent control.

Our flagship platforms are the quadruped robots HyQ (2010), HyQ2Max (2015), and HyQReal (2019). We are actively pushing legged robots into real world applications, such as disaster response (e.g. INAIL Robot Teleoperativo project), precision agriculture (e.g. VINUM project on grapevine winter pruning automation), space exploration (e.g. ESA-ANT project on legged rovers for planetary exploration), and monitoring and maintenance (e.g. PNRR RAISE on port infrastructure monitoring).

Achievements

We are an internationally recognized player in quadruped robot design and control. We have over 110 peer-reviewed publications in international journals and conferences, and were invited to co-author the Springer Encyclopedia chapter “Legged Robots”. We have been invited to deliver conference keynotes, panel discussions, and workshops.

We engage in technology transfer via the Moog@IIT Joint Lab. We have secured funding for several EU, national, and industrial projects.

In 2019, the HyQReal robot successfully pulled a passenger airplane weighing 3.3 tonnes, with the video of this feat receiving over 500K views.

Representative Publications

[1] Abdalla A. et al., IEEE Transactions on Robotics, 2023.

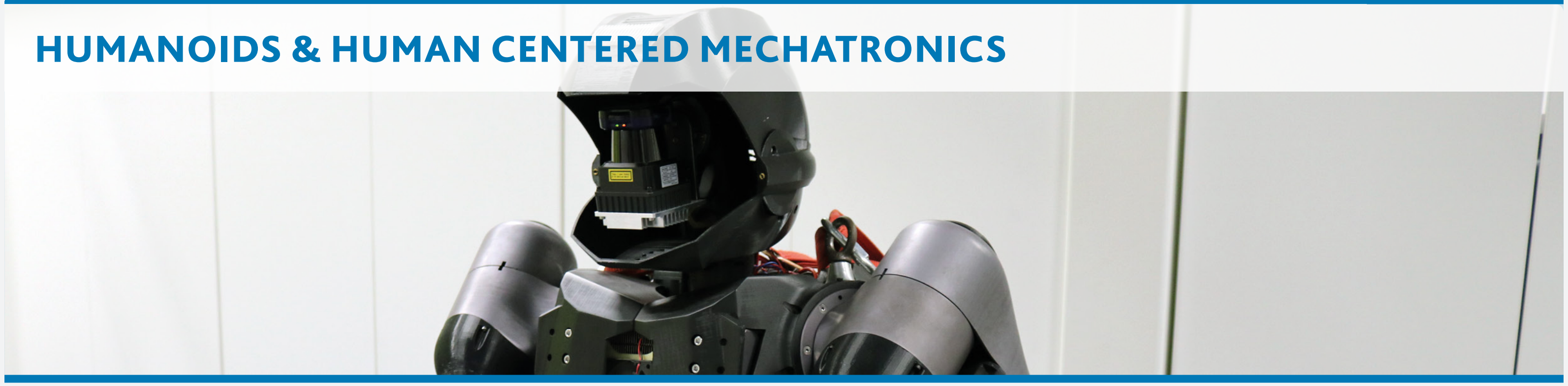
[2] Guadagna P. et al., Precision Agriculture, 2023.

[3] Mastalli C. et al., IEEE Transactions on Robotics, vol. 36, (no. 6), pp. 1635-1648, 2020.

[4] Semini C. et al., IEEE/ASME Transactions on Mechatronics, vol. 22, (no. 2), pp. 635-646, 2017.

[5] Semini C. et al., Proceedings of the Institution of Mechanical Engineers. Part I: Journal of Systems and Control Engineering, vol. 225, (no. 6), pp. 831-849, 2011.

HUMANOIDS & HUMAN CENTERED MECHATRONICS



Principal Investigator
Nikolaos Tsagarakis
CRIS@SanQuirico

Description

Our mission is to realize robots to assist humans in daily life and work. They should thus be physically strong and agile, able to operate for nearly as long as humans, and also sustainable.

in particular, we design lightweight and high-power/torque density robots. We do this by optimizing designs and advancing actuation for impact-proof and efficient drive, modularity, and configurability. We have developed the compliant humanoids WALK-MAN and COMAN+, the wheeled-legged quadrupedal platform CENTAURO, the reconfigurable mobile robot CONCERT, and the multi-arm/leg robot MARM for SPACE applications. The hardware advances are synchronized with developments in locomanipulation planning and control, interactive autonomy tools and teleoperation interfaces, which allow the human operator to efficiently interact with the robotic platforms.

Achievements

We have pioneered robot technologies thanks to our attainment and/or coordination of competitive European projects (12+), commercial and industrial (10+) projects, and Joint Labs (2) with industry. We have thus realized world-class robotic platforms such as the humanoids COMAN and WALK-MAN, the quadruped robot CENTAURO, and the reconfigurable CONCERT platform for technology transfer and exploitation in the form of modular robotic systems. These accomplishments have been internationally recognized via several highly ranked publications, prestigious awards (20+), and keynotes.

Representative Publications

[1] Hoffman E.M. et al., Proceedings - IEEE International Conference on Robotics and Automation, vol. 2023-May, pp. 11887-11893, 2023.

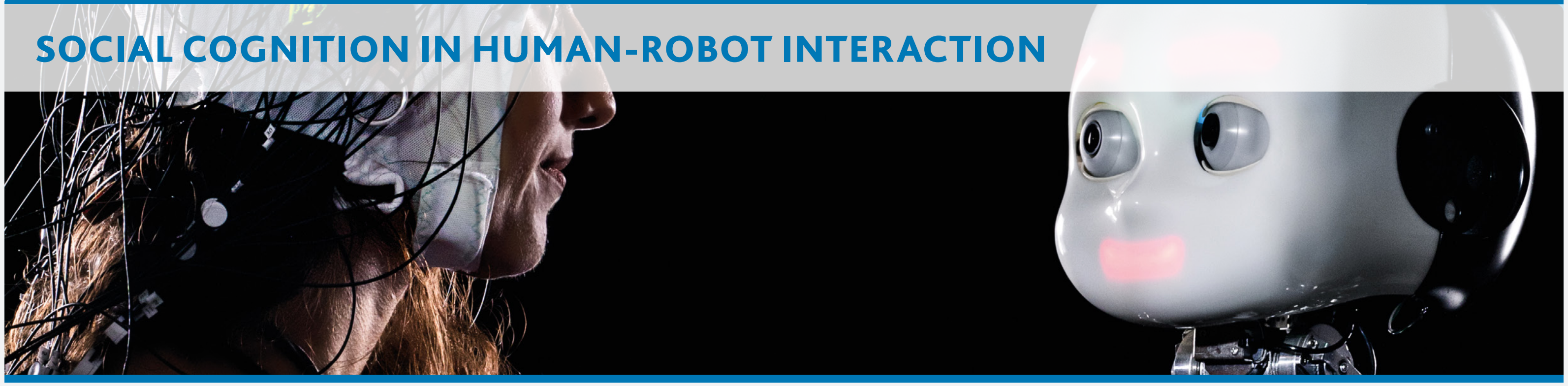
[2] Torielli D. et al., IEEE Robotics and Automation Letters, vol. 7, (no. 2), pp. 2479-2486, 2022.

[3] Romiti E. et al., IEEE/ASME Transactions on Mechatronics, vol. 27, (no. 5), pp. 3219-3231, 2022.

[4] Roozing W. et al., International Journal of Robotics Research, vol. 40, (no. 1), pp. 37-54, 2021.

[5] Polverini M.P. et al., IEEE Robotics and Automation Letters, vol. 5, (no. 2), pp. 859-866, 2020.

SOCIAL COGNITION IN HUMAN-ROBOT INTERACTION



Principal Investigator
Agnieszka Wykowska
CHT@Erzelli

Description

By combining cognitive neuroscience with robotics, we examine human brain mechanisms in interactions with natural and artificial agents. We use behavioral methods and electroencephalography, focusing on the following cognitive mechanisms: attention in interaction; sense of agency; joint action; executive control in social contexts; and intentional stance towards robots.

We use robots as sophisticated apparatus for experimental protocols, as they offer a high degree of ecological validity and excellent experimental control. Robots also offer the opportunity to understand mechanisms of the human brain by embodying computational models of human cognition. We also use robots for cognitive rehabilitation, such as the robot-assisted training of sociocognitive skills for children with neurodevelopmental disorders.

Our research impacts social and cognitive neuroscience, robot design, and robot-assisted healthcare.

Achievements

With our unique approach of using cognitive neuroscience methods in human-robot interactions, we have obtained groundbreaking results, published in prestigious journals, such as Sci Robot.

In 2016, our PI, A. Wykowska, secured the ERC grant InStance. In the past five years, she has been invited as guest/keynote speaker to more than 100 conferences and seminars. In 2018, she was appointed Editor-in-Chief of Int J Soc Robot.

In 2022, she was elected President of the European Society for Cognitive and Affective Neuroscience, and Delegate to the ERA Forum.

Representative Publications

[1] Ghiglino D. et al., Autism Research, 2023.
[2] Ciardo F. et al., Science Robotics, vol. 7, (no. 68), 2022.
[3] Belkaid M. et al., Science Robotics, vol. 6, (no. 58), 2021.
[4] Wykowska A.Current Directions in Psychological Science, 2021.
[5] Bossi F. et al., Science Robotics, 2020.

Facilities

Facilities

Facility Coordinators

ANALYTICAL CHEMISTRY

Facility Coordinator
Andrea Armirotti
CCT@Morego

Description

The Analytical Chemistry Facility (ACF) supports the IIT Network in all research projects in the fields of chemistry, medicinal chemistry, biochemistry, biology, and materials sciences.

ACF has state-of-the-art instrumentation and offers top-end skills for identifying, purifying, characterizing, and quantifying many classes of chemical compounds (e.g. small molecules, proteins, peptides, lipids, metabolites, polymers) from the most diverse matrices (e.g. tissues, plasma, urine, cell extracts).

Achievements

In recent years, on top of the "routine" chemical characterization workflow for drug discovery units, we have delivered timely and high-quality data for many different projects, dealing with various aspects of IIT research fields. As a (partial) metric of our contribution, we have published close to 70 papers in the last five years.

Furthermore, Andrea Armirotti has secured his own competitive projects as PI (see Graphene Flagship, WP4, and a number of projects in the field of cystic fibrosis). He also serves as President of the Italian Mass Spectrometry Society.

Representative Publications

[1] Palange A.L. et al., Advanced Science, 2023.
[2] Brindani N. et al., Journal of Medicinal Chemistry, vol. 66, (no. 8), pp. 5981-6001, 2023.
[3] Castagnola V. et al., Nano Letters, vol. 23, (no. 7), pp. 2981-2990, 2023.
[4] Liessi N. et al., Journal of Cystic Fibrosis, 2023.
[5] Di Mascolo D. et al., Nature Nanotechnology, vol. 16, (no. 7), pp. 820-829, 2021.

DATA SCIENCE & COMPUTATION FACILITY

Facility Coordinator
Sergio Decherchi
CHT@Erzelli

Description

We support IIT in all computing activities and use artificial intelligence (AI)/machine learning methods to leverage data produced in experiments or simulations by the Research Units. Our computational infrastructure comprises two high-performance machines, Franklin and Energon. Franklin has 83 computing nodes and 288 GPUs which allow for a greater than 1 Pflops double-precision performance.

In detail, we:
i. Manage the computing infrastructure;
ii. Support scientists in using the infrastructure (e.g. code compilation, optimization, and containerization);
iii. Support users in developing numerical algorithms;
iv. Develop frontends (e.g. webservers) for computational backends to easily serve the internal and external scientific community; and
v. Use AI to build predictive, descriptive, and/or generative models.

Achievements

Our facility was established in January 2023, although our core system, Franklin, has been fully operative for more than two years. Franklin serves IIT's computational community, with around 200 active users across the various domains.

The ancillary system, Energon, serves several bioinformaticians, supporting all the computational steps of genomic or other omic pipelines. We contribute to several European and national projects, including PNRR.

Representative Publications

[1] Rocutto L. et al., IEEE Access, 2023.
[2] Abate C. et al., Wiley Interdisciplinary Reviews: Computational Molecular Science, 2023.
[3] Di Palma F. et al., Wiley Interdisciplinary Reviews: Computational Molecular Science, 2023.
[4] Majumdar S. et al., Journal of Chemical Information and Modeling, 2023.
[5] Decherchi S. et al., Journal of Physical Chemistry Letters, vol. 14, (no. 6), pp. 1618-1625, 2023.

STRUCTURAL BIOPHYSICS

Facility Coordinator
Stefania Girotto
CCT@Morego

Description

Founded in early 2022, the Structural Biophysics (SB) facility supports IIT and external research activities with state-of-the-art biophysical instrumentation. We design and perform ad hoc experiments to characterize macromolecules, small molecules, and new materials. Working with cells, cell lysates, or in-house purified recombinant proteins, we routinely perform biophysical and structural characterizations of many interactions, including protein-small molecule, protein-protein, and interactions with DNA, RNA, aptamers, and antibodies. We also conduct molecular biology activities, biochemical and in-cell assays, and metabolomics analyses.

Our instruments include systems for purifying proteins and handling crystallization liquids, microscale thermophoresis, surface plasmon resonance, isothermal titration calorimetry, and a Bruker FT NMR Avance NEO 600 MHz spectrometer equipped with a 5 mm CryoProbe QCI _H/__F–__C/__N–D.

Achievements

We regularly provide instrument training to new users, we supervise PhD and postdoc fellows in collaboration with PIs, and we train visiting PhD students from external institutions.

We are involved in several collaborations with IIT and external research groups, which have led to peer-reviewed publications. We have also supported several grants by providing services and via direct collaborations.

Representative Publications

[1] Brindani N. et al., Journal of Medicinal Chemistry, 2023.
[2] Brusa I. et al., Journal of Medicinal Chemistry, vol. 66, (no. 14), pp. 9797-9822, 2023.
[3] Dalvit C. et al., Journal of Magnetic Resonance, vol. 12-13, pp. 100070, 2022.
[4] Mastronardi V. et al., Nanoscale, vol. 14, (no. 28), pp. 10155-10168, 2022.
[5] Bagnolini G. et al., ACS Medicinal Chemistry Letters, vol. 13, (no. 8), pp. 1262-1269, 2022.

MEDICINAL CHEMISTRY AND TECHNOLOGIES FOR DRUG DISCOVERY AND DELIVERY

Facility Coordinator
Rita Scarpelli
CCT@Morego

Description

The Medicinal Chemistry and Technologies for Drug Discovery and Delivery Facility (MCTD3F) conducts research activities in medicinal chemistry, synthetic chemistry, and chemical biology. We aim to deliver tangible technologies (e.g. high-quality chemical probes, preclinical candidates). We also provide technical-scientific support for the design, execution, and analysis of a variety of biological assays (e.g. target-based and cell-based assays) to evaluate different types of chemical entities (e.g. small molecules, nanomaterials).

MCTD3F labs are equipped with state-of-the-art instrumentation for automated sample management (e.g. centralized proprietary compound collection), integrated with robotized liquid handling and screening workstations. They also feature modern equipment for synthesizing and purifying organic molecules, and advanced technologies for developing a wide range of screening assays for different applications.

Achievements

Founded in 2022, MCTD3F has provided lab activity services and has established scientific collaborations to support different IIT research projects in the areas of Life Sciences, Computational Sciences, and Nanomaterials. MCTD3F has also sought to broaden collaborative opportunities with external Investigators. Some of these projects have been funded by industrial partners or competitive grant programs. Our collaborations include: Dr B. Grimaldi (IIT-SOTIO Biotech Project, 2020-2023); and Prof. L. Volpicelli-Daley (NIH/DHHS Grant Project, 2023-2028).

Representative Publications

[1] Scarpelli R. et al., IX EFMC International Symposium on Advances in Synthetic and Medicinal Chemistry, 2023.
[2] Scarpelli R. et al., XXVIII National Meeting on Medicinal Chemistry, 2023.

TRANSLATIONAL PHARMACOLOGY

Facility Coordinator
Rosalia Bertorelli
CCT@Morego

Description

We have extensive experience in identifying, developing, validating, conducting, and analyzing preclinical studies. This includes: the biodistribution of nanostructures; the pharmacokinetics or pharmacodynamic of drugs; and the toxicity profiles of drugs.

We have also been involved in investigating new approaches to studying nanomaterials and their potential applications for human diseases, and new approaches to studying the therapeutic efficacy of novel synthetic drugs in several biological targets.

Achievements

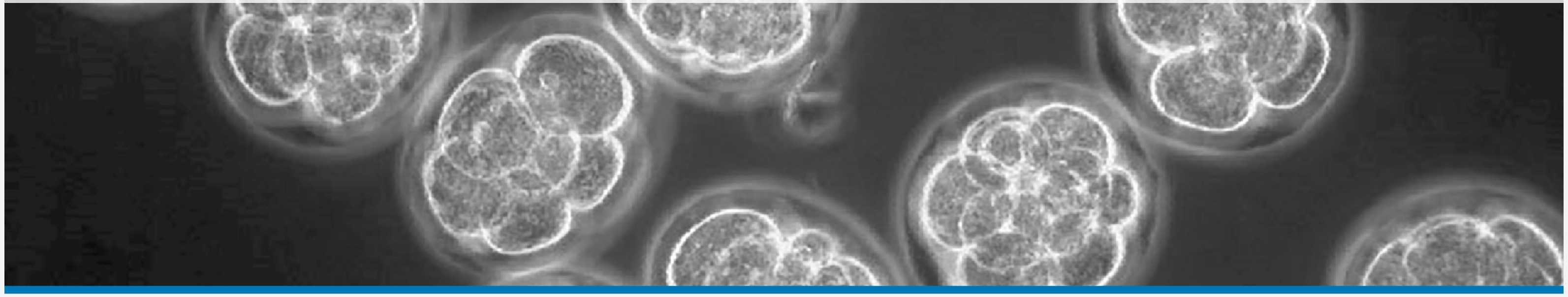
We have several lengthy and established collaborations with different groups at IIT. This continuous effort has produced several published papers each year.

We also contribute to the IIT-Bracco Joint Lab and to the Sustainability initiative. Two AIRC grants are in place in collaboration with different PIs, and a commercial project has produced a patent.

Representative Publications

[1] Brindani N. et al., Journal of Medicinal Chemistry, 2023.
[2] Lenzuni M. et al., Lab on a Chip - Miniaturisation for Chemistry and Biology, 2023.
[3] Contardi M. et al., Pharmaceutics, vol. 14, (no. 3), 2022.
[4] Jahid S. et al., Cell Reports, vol. 39, (no. 1), 2022.
[5] Zamborlin A. et al., Nano Letters, vol. 22, (no. 13), pp. 5269-5276, 2022.

ANIMAL FACILITY



Facility Coordinator
Monica Morini
CCT@Morego

Description

We are responsible for the care, welfare, and health of laboratory animals. The Animal Facility conforms to the standards of FELASA and is designated as a Research Facility by the Italian Ministry of Health (Authorization n. 29/2019-UT 09/09/2019). The Animal Facility is equipped to house rodents and includes a state-of-the-art specific-pathogen-free vivarium.

The Animal Facility includes fully equipped surgical and behavioral testing rooms, in vivo imaging analysis, and mouse genetic laboratories for the generation of new genetically modified mice models. In the Animal Facility, investigators work with laboratory animals, respecting the national regulation regarding the protection of animals used for scientific purpose (D.Lgs. 04/03/2014 n. 26) and under the control of the Animal Welfare Body (OPBA), following the principles of 3Rs (replacement, reduction, refinement). We recently obtained authorization for the breeding and use of zebrafish.

Achievements

We provide support for authorized projects involving the use of animals (73 ongoing).

We have 3220 cages for mice and 210 cages for rats. The average cage occupancy is approximately 70-80% for mice and 20% for rats.

The Animal Facility houses 96 genetically modified mouse lines.

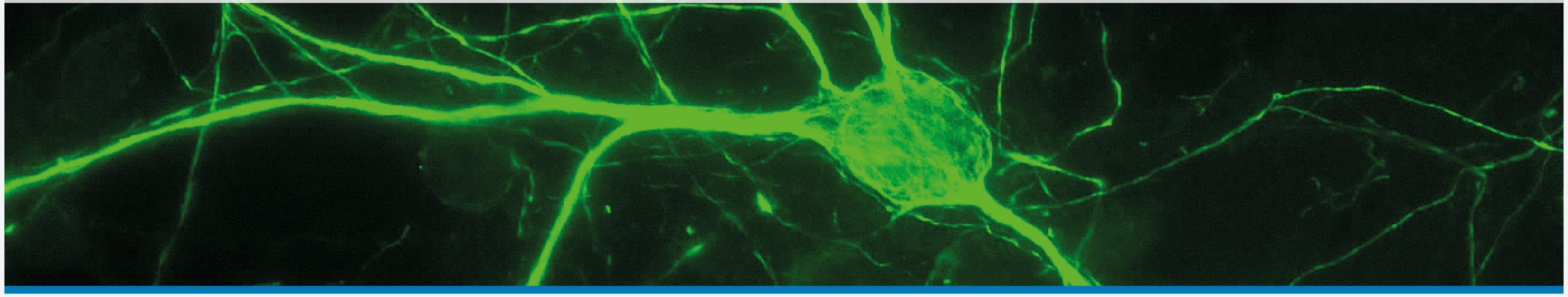
Users/Research Units: 81 users/19 Research Units.

Animal users must complete facility orientation training provided by our staff prior to gaining access. This training includes information on animal husbandry and care, and safe rules for work in the facility.

Representative Publications

[1] Palomba R. et al., Materials Horizons, vol. 8, (no. 10), pp. 2726-2741, 2021.
[2] Di Mascolo D. et al., Nature Nanotechnology, vol. 16, (no. 7), pp. 820-829, 2021.
[3] Parrini M. et al., Molecular Therapy, vol. 29, (no. 10), pp. 3072-3092, 2021.
[4] Mai B.T. et al., ACS Applied Materials and Interfaces, 2019.

NEUROFACILITY



Facility Coordinator
Enrica Petrini
CCT@Morego

Description

We are a team of experts in biology, neuroscience, physics, and engineering. We provide technical support to IIT Research Units, mainly in the Life Technologies (LifeTech) Research Domain.

In addition to core experimental activities related to neuroscience, the Neurofacility provides different services including fluorescence-activated cell sorting, DNA/RNA manipulation and sequencing, a mechanical workshop, and a fluorescence microscopy platform featuring three confocal microscopes with two-photon lasers, two multiline widefield microscopes, and one spinning disk.

The Neurofacility also manages shared laboratories dedicated to sample preparation and analysis in the fields of neuroscience (primary neuronal cultures, acute brain slices, histochemical sections, genetically modified viral vectors, surgery and genotyping), molecular biology (DNA/RNA extraction, manipulation, and quantification), drug delivery, and cancer (immortalized and primary cell cultures).

Achievements

Over the years, we have strived to expand our array of life-science-related services. We recently included human samples in our list of biological preparations. We also launched two new labs for the differentiation of rodent and human induced pluripotent stem (iPS) cells.

Our support for neuroscience research has been strengthened by the implementation of shared endoscopes for in vivo imaging and a new laboratory for stereotaxic viral injections. Finally, the imaging platform has set up a new microscope for automated four-color fluorescence mosaic imaging.

Representative Publications

[1] Fernandez Cabada T. et al., Nanoscale Horizons, vol. 8, (no. 1), pp. 95-107, 2022.
[2] Penna I. et al., Biotechnology and Applied Biochemistry, vol. 66, (no. 3), pp. 273-280, 2019.
[3] Castellani G. et al., Brain, Behavior, and Immunity, vol. 81, pp. 138-150, 2019.
[4] Prestigio C. et al., Molecular Neurobiology, vol. 56, (no. 9), pp. 6276-6292, 2019.
[5] Trusel M. et al., ACS Applied Materials and Interfaces, vol. 10, (no. 20), pp. 16952-16963, 2018.

GENOMICS FACILITY

Facility Coordinator
Diego Vozzi
CHT@Erzelli

Description

The Genomics Facility is equipped with state-of-art instrumentation. Its aim is to enable IIT scientists to perform their own genomic experiments, starting from DNA/RNA derived from any source and species (e.g. animal, plant, prokaryotic). We support scientists throughout the entire data generation process, including:

i. Starting material quality control (QC);
ii. Sample manipulation and library preparation;
iii. Generation and release of QC-passed sequencing data;
iv. Setting up nonstandard sequencing protocols; and
v. Maintaining and managing the laboratory information management system.

Our main technologies are short reads sequencing; long reads sequencing; single-cell transcriptomics; and liquid handling platforms. Example applications for these technologies include: DNAseq; RNAseq; single-cell transcriptomics; and viral/bacterial sequencing.

Achievements

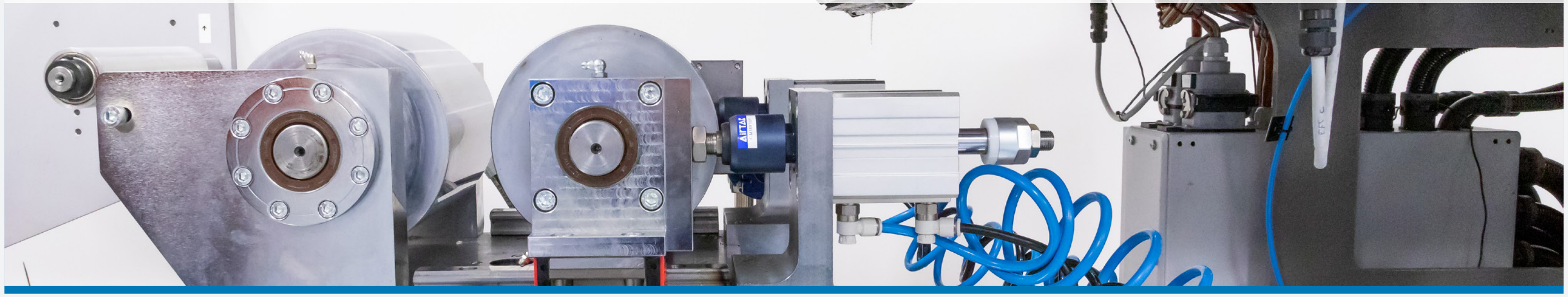
Genomics activities have been conducted at IIT since 2018, resulting in the founding of the Genomics Facility in January 2023. To date, we have supported more than ten internal research domains.

We play a leading scientific role in the Gaslini Hospital-IIT joint lab, a formal scientific collaboration between the two entities. We are also involved in some externally financed scientific projects.

Representative Publications

[1] Mangoni D. et al., Nature Communications, vol. 14, (no. 1), 2023.
[2] Ognibene M. et al., Cancers, vol. 15, (no. 6), 2023.
[3] Boeri S. et al., Epileptic Disorders, 2023.
[4] Cerminara M. et al., Frontiers in Genetics, vol. 12, 2021.
[5] Papa R. et al., Clinical Immunology, vol. 231, 2021.

MATERIAL TECHNOLOGIES FOR INDUSTRY



Facility Coordinator
Ilker Bayer
CCT@Morego

Description

We prioritize materials and sustainable processes, including biocomposites, surface technology, and materials for biomedical technologies.

We are specialists in three technology fields:
i. The creation of responsive materials that interact with specific environments;
ii. Emulsions generated with templating technologies for drug release, drug control, and food science; and
iii. Biobased composites with customized properties.

We aim to establish close collaborations with industrial research and development facilities. We thus offer solutions for research and development endeavors focused on innovating new products or services within industry. Our goal is to ensure each company's competitiveness by producing products that enhance and elevate their existing product line on metals, polymers, ceramics, and composite materials, as well as their respective manufacturing, forming, and transformation processes.

Achievements

We have fostered open innovation through R&D collaborations, resulting in the development of new products, processes, and services. These have provided value to our customers and positively impacted society.

Our collaborations have exposed students to the dynamics of industry-academia research, leading to employment opportunities with participating industrial departments. We have also been actively involved in various start-up activities in Italy and North America, and have contributed to IIT's intellectual property (patent) pool. Some of our patents have been licensed.

Representative Publications

[1] Maraveas C. et al., Biotechnology Advances, vol. 54, 2022.
[2] Clausi M. et al., Advanced Composites and Hybrid Materials, vol. 5, (no. 2), pp. 798-812, 2022.
[3] Bayer G. et al., Journal of Food Engineering, vol. 323, 2022.
[4] Bayer I.S.Advanced Materials Interfaces, vol. 9, (no. 18), 2022.
[5] Bayer G. et al., Colloids and Surfaces A: Physicochemical and Engineering Aspects, vol. 619, 2021.

ELECTRON MICROSCOPY

Facility Coordinator
Rosaria Brescia
CCT@Morego

Description

Our equipment comprises two scanning electron microscopes and four transmission electron microscopes (TEMs), most with analytical capabilities, and a well-equipped laboratory for sample preparation. With our diverse expertise, from life science to materials science, we support IIT Research Units, other institutes, and companies.

We help to define the optimal strategies to address various scientific questions, and we provide training on specific techniques and instrumentation. We also provide structural, compositional, and morphological analysis of a wide range of specimens (biological samples, inorganic materials, organic materials, combinations thereof). For this, we use a wide range of approaches including electron diffraction, high-resolution TEM, energy-dispersive X-ray spectroscopy, energy-filtered TEM, electron energy-loss spectroscopy, tomography, cryo-EM, cryo-electron tomography, and liquid cell.

Achievements

We are committed to minimizing instrumentation downtime, and ensuring the responsible use of shared instrumentation.

With our growing expertise, we are continuously optimizing our methodologies and their reproducibility. The recent integration of direct detection cameras on both 200 kV TEMs has contributed to a continuous expansion of our experimental portfolio. This portfolio now includes dose-controlled HR-TEM analyses on beam-sensitive materials, and high-resolution semiautomated, cryo-EM single-particle analysis.

Representative Publications

[1] Bellato F. et al., ACS Applied Energy Materials, vol. 6, (no. 1), pp. 151-159, 2023.
[2] Zamborlin A. et al., Nano Letters, vol. 22, (no. 13), pp. 5269-5276, 2022.
[3] Marotta R. et al., Acta Crystallographica Section D: Structural Biology, vol. 78, pp. 1399-1411, 2022.
[4] An M.N. et al., ACS Energy Letters, vol. 6, (no. 3), pp. 900-907, 2021.

CHEMISTRY FACILITY

Facility Coordinator
Luca De Trizio
CCT@Morego

Description

The Chemistry Facility is a chemistry lab that allows research groups to develop synthesis routes for the production of inorganic or hybrid nanoscale materials. In detail, we facilitate the execution of solid-state, organic, polymeric, colloidal, hydro-, and solvo-thermal reactions.

Our lab features: 17 fume hoods, each equipped with Schlenk lines connected to air, Ar, and N2 lines; three N2 filled gloveboxes for handling samples under inert atmosphere; three spectrophotometers and two spectrofluorometers for measuring the optical properties of samples in the UV-vis-NIR range; inductively coupled plasma-mass spectrometry and -optical emission spectrometry instruments for the elemental analysis of products; a thermogravimetic analyzer; a dynamic light scattering setup for determining the solvodynamic radius of nanoparticles; and a cell culture room for studying the nanoparticle-cell interactions.

Our users are fully supported and trained by five expert technicians.

Achievements

The Chemistry Facility is equipped and managed to successfully follow the UNI EN ISO 14001 norms.

Staff technicians are fully trained to actively support our users via instrumental and safety trainings.

Our collaborations with Research Units have led to the development of colloidal syntheses of nanocrystals of several classes, including metal halides, pnictides, oxides, chalcogenides, and chalcohalides. Our collaborations have also established techniques for combining such materials into nano-heterostructures with different architectures (e.g. core@shell, dimers).

Representative Publications

[1] Zhu D. et al., Advanced Materials, 2023.
[2] Liu Z. et al., Advanced Energy Materials, vol. 12, (no. 38), 2022.
[3] De Trizio L. et al., Trends in Chemistry, vol. 3, (no. 8), pp. 631-644, 2021.
[4] Shamsi J. et al., Chemical Reviews, 2019.
[5] De Trizio L. et al., Chemical Reviews, vol. 116, (no. 18), pp. 10852-10887, 2016.

MATERIALS CHARACTERIZATION

Facility Coordinator
Mirko Prato
CCT@Morego

Description

The Materials Characterization Facility (MCF) facilitates and optimizes access to advanced characterization techniques, and supports research groups in developing, optimizing, and applying new materials.

iIT scientists have organic access to the full spectrum of available techniques to exhaustively characterize materials, with a direct line of access to the different laboratories.

Our broad expertise includes:
i. Structural characterizations with X-ray diffraction-based techniques;
ii. Mechanical properties of materials using stress/strain testing in tension, compression, bending, nanoindentation, and dynamic characterization in temperature;
iii. The mapping of electrical, mechanical, and morphological properties at the nanoscale using scanning probe microscopies; and
iv. The analysis of sample composition and surface properties.

Achievements

To date, MCF has supported nearly one-third of IIT Research Units, either by delivering training on equipment use or by the direct involvement of our staff in advanced data acquisition and analysis for the research activities. Our capabilities were recently enhanced by the addition of the Extreme Conditions X-ray diffraction lab.

This lab can be used to extract information about the structure of materials under nonstandard conditions (high and low temperature, high pressure, reactive gas atmospheres, in operando).

Representative Publications

[1] Pescetelli S. et al., Nature Energy, vol. 7, (no. 7), pp. 597-607, 2022.
[2] Gera R. et al., Journal of the American Chemical Society, vol. 143, (no. 37), pp. 15103-15112, 2021.
[3] Caligiuri V. et al., ACS Nano, vol. 14, (no. 8), pp. 9502-9511, 2020.
[4] Brennan M. C. et al., ACS Energy Letters, vol. 5, (no. 5), pp. 1465-1473, 2020.
[5] Castelli A. et al., Advanced Materials, vol. 31, (no. 1), 2019.

CLEAN ROOM

Facility Coordinator
Andrea Toma
CCT@Morego

Description

The Clean Room is a user-based facility providing access to an extensive set of processes and high-tech equipment, which are intertwined to cover a wide range of cross-disciplinary applications.

We focus on the key enabling technologies prioritized by the European Commission, such as photonics, micro/nano-electronics, advanced materials, and life science technologies. As such, we foster top-notch research and education at the nanoscale. We cover the entire evolution chain of a new device, from curiosity-driven research and process development through to rapid in-house prototyping.

With our leading-edge tools and comprehensive processing knowledge, we grant access to nearly 100 scientists, offering extensive support on the advanced creation and functionalization of devices and sensors.

Achievements

The Clean Room aims to facilitate the design of functions via precise creation, synthesis, and assembly. This allows technological advances in photonic systems for renewable energy, diagnostic tools, and quantum optics.

Our research team secured a high-risk high-gain competitive grant (ERC Consolidator) covering light-matter interaction at the single-few entities limit, where judiciously designed nanophotonic architectures can introduce unobserved properties into energy-related nanomaterials.

Representative Publications

[1] Fedotova A. et al., ACS Photonics, vol. 9, (no. 12), pp. 3745-3763, 2022.
[2] Aglieri V. et al., Nanophotonics, vol. 9, (no. 3), pp. 683-690, 2020.
[3] Carrara A. et al., Advanced Optical Materials, vol. 8, (no. 18), 2020.
[4] Schirato A. et al., Nature Photonics, vol. 14, (no. 12), pp. 723-727, 2020.
[5] Calandrini E. et al., Nanophotonics, vol. 8, (no. 1), pp. 45-62, 2019.

INDUSTRIAL ROBOTICS FACILITY

Facility Coordinator
Ferdinando Cannella
CCT@Morego

Description

Industrial Robotics Facility (InBot) tackles the challenges of bringing current robotics research to mainstream industrial use cases. We thus bridge the gap between the academic and industrial forefronts, and specialize in automating complex labor-intensive tasks. These tasks normally require dexterous motion and compliant material handling. Our research goals are therefore aligned towards dexterous manipulation, elasticity, and compliant material control.

inBot also develops new autonomous robotic systems for inspecting and monitoring structures and infrastructures, from archaeological sites (e.g. Pompeii, museums) through to bridges and railways (e.g. girders, sound barriers, pillars). For example, we developed the world's first fully autonomous robot for inspecting bridges. This robot, which resulted in a patent, is now operative on Genoa's San Giorgio Bridge.

Finally, one of our key strengths is that 50% of our prototypes are in use in industrial plants.

Achievements

Established in January 2022, InBot is the most recent version of the Industrial Group, which was created 10 years previously. Our most recent achievements are therefore the result of a lengthy period of research and application in industrial robotics.

Our main achievements are:

i. 6 EU grants (from FP7 to HEurope) and 6 Italian grants;
ii. 15 projects with industrial partners;
iii. 4 industrial challenges/prizes and four finalist positions in international competitions;
iv. More than 100 publications;
v. 6 patents; and
vi. All the PhD students and or postdocs who worked in our previous incarnation are now key people in their respective universities or companies.

Representative Publications

[1] Galdelli A. et al., Remote Sensing, vol. 14, (no. 9), 2022.

[2] Subburaman R. et al., IEEE International Conference on Intelligent Robots and Systems, pp. 8246-8253, 2021.

[3] D'Imperio M. et al., Mechanisms and Machine Science, vol. 49, pp. 381-388, 2018.

[4] D'Angelo M.L. et al., Lecture Notes in Computer Science, vol. 10894 LNCS, pp. 82-93, 2018.

[5] D'Angelo M.L. et al., IEEE Transactions on Haptics, vol. 10, (no. 1), pp. 123-129, 2017.

ADVANCED ROBOTICS FACILITY

Facility Coordinator
Stefano Cordasco
CRIS@SanQuirico

Description

We provide technical support to various IIT Research Units (ADVR, HHCM, DLS, HRII, SoftBots).

We seek to develop electronic hardware, firmware, and software for a broad spectrum of applications involving every Research Unit. Developing the hardware together with the respective firmware and real-time software, our hardware design includes:
i. Electrical motor drivers for different applications;
ii. Full robot platform design with energy management; and
iii. Various sensor acquisition and medical device boards.

Beyond providing technical support to the above Research Units, we are also involved in some external projects as Project Partner.

Achievements

We have developed hardware, firmware, and software for different robot platforms for different applications.

These include:
i. Arms for space applications (STABLE and THALES-Alenia arms);
ii. Whole biped (Coman, Walkman, Coman+), tripod (MIRROR), and quadruped (Centauro, Pholus, Nexus, HyQReal) robots with locomotion and manipulation abilities; and
iii. Wheeled navigation and manipulation platforms (RELAX and CONCERT projects).

In addition to these platforms, we have had and still have relevant roles in projects for INAIL, JOiiNT Lab, RePAIR, and other space-related platforms.

Representative Publications

[1] Mingo Hoffman E. et al., IEEE ICRA, 2022.
[2] Estremera J. et al., 16th Symposium on Advanced Space Technologies in Robotics and Automation, 2022.
[3] Lucia M. et al., 73rd International Astronautical Congress, 2022.
[4] Romiti E. et al., IEEE/ASME Transactions on Mechatronics, 2021.
[5] Kashiri N. et al., IEEE Robotics and Automation Letters, vol. 4, (no. 2), pp. 1595-1602, 2019.

ELECTRONIC DESIGN LABORATORY

Facility Coordinator
Marco Crepaldi
CHT@Erzelli

Description

The Electronic Design Laboratory (EDL) is an advanced electronic design facility. We are skilled in designing and implementing electronic systems, particularly those with applicability to scientific research, including all the IIT research domains. EDL is qualified to develop electronic systems with high technology readiness level.

In addition to our design service, EDL research contributes to increasing the body of knowledge in electronic system design, computing devices, and integrated circuits.

Achievements

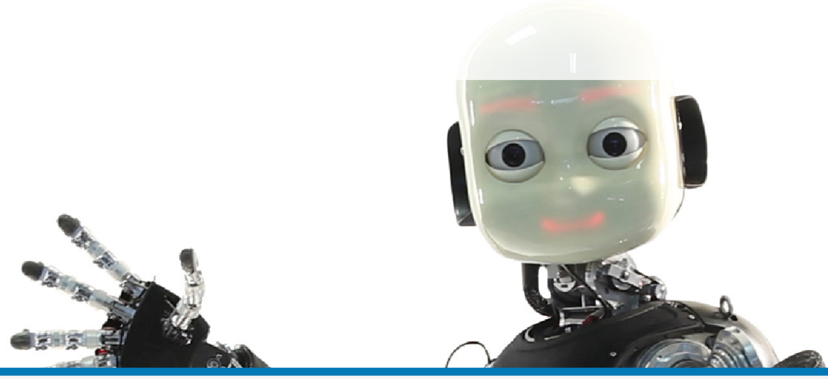
We have implemented the first-ever multiple One Instruction Set Computer including software compilation toolchain. We discovered the first-ever evidence of in-memory computing in an amorphous ferrofluid liquid.

We implemented the first-ever transcutaneous fetal visual stimulator based on a flexible display. We were the first to apply neural networks in synchronization in a Bluetooth-based wireless network. We implemented the first-ever 1Gbps pulse-based ultra-wide-band transceiver prototype, with applications for wireless streaming of high-density neural probe recordings.

Representative Publications

[1] Crepaldi M. et al., Advanced Materials, 2023.
[2] Balasubramanian K.K. et al., Nature Communications, vol. 14, (no. 1), 2023.
[3] Balasubramanian K.K. et al., IEEE Access, vol. 10, pp. 45979-45996, 2022.
[4] Crepaldi M. et al., IEEE Access, vol. 9, pp. 113454-113474, 2021.
[5] Crepaldi M. et al., IEEE Transactions on Circuits and Systems I: Regular Papers, vol. 66, (no. 7), pp. 2735-2748, 2019.

ICUB TECH



Facility Coordinator
Marco Maggiali
CRIS@SanQuirico

Description

We design, develop, and build humanoid robots. iCub, R1, and ergoCub are the main platforms in our portfolio. We take care of the full lifecycle of our products from design to maintenance and upgrades. We support the Research Units and external labs using our robots, which we are constantly improving thanks to our strong collaborations.

We take a 360-degree approach to robotics, including mechanical and electronic design, power, sensor development (e.g. tactile), control, leveraging advanced design methodologies (e.g. model-based system engineering), and integrating new technologies provided by IIT's Research Units. We are a multidisciplinary team of engineers, software developers, and technicians. We adopt Agile Scrum methodology: every 12 weeks, we share the results of our accomplished activities, and we plan for the next program period.

We are a Technology Provider for European projects and sponsored research agreements.

Achievements

More than 50 iCubs have been delivered to best-in-class robotics labs worldwide (EU, UK, Canada, China, Korea, Japan, Chile, and Singapore). iCub3, the evolution of iCub, was used in the ANA Avatar XPrize competition, qualifying for the finals in Los Angeles where it performed best among the bipedal humanoid robots.

Our ergoCub platform (https://ergocub.eu) is specifically designed in terms of shape, size, power, and mass distribution to work in partnership with humans. The goal is to help workers accomplish heavy tasks while reducing the risk of injuries. This project is sponsored by INAIL.

Representative Publications

[1] Fussi M. et al., MathWorks, 2023.
[2] Romeo R.A. et al., IEEE Transactions on Instrumentation and Measurement, vol. 72, 2023.
[3] Vasco V. et al., Frontiers Robotics AI, vol. 9, 2022.
[4] Dafarra S. et al., arXiv, 2022.
[5] Parmiggiani A. et al., International Journal of Humanoid Robotics, vol. 9, (no. 4), 2012.

MECHANICAL WORKSHOP

Facility Coordinator
Alberto Parmiggiani
CRIS@SanQuirico

Description

We support IIT researchers in the design, development, and construction of mechanical systems. We operate in four areas: i) mechanical design; ii) CNC machining; additive manufacturing; and iv) mechanical assemblies and testing.

Our facility is equipped with four state-of-the-art CNC machining stations, a waterjet cutting machine, additive manufacturing systems (polymers), and tools for mechanical testing and assembly operations. We also conduct scouting on mechanical design and production technologies in order to keep IIT's manufacturing abilities at the cutting edge.

Achievements

Founded in 2013, our team now comprises 12 members. In 2022, we relocated the facilitate to CRIS site, and drew up equipment upgrade plans. In the past 8 years, we have retained our skilled talents, despite the unfavorable wider context.

We support IIT's research by completing an average of 670 production jobs yearly, requiring 12000 hours of work on average. Since 2019, we are increasingly involved in preparing, submitting, and executing funded projects.

Representative Publications

[1] Ottonello E. et al., IEEE/ASME Transactions on Mechatronics, 2023.
[2] Pizzorni M. et al., Composites Part B: Engineering, vol. 230, 2022.
[3] Cepolina E.E. et al., Acta IMEKO, vol. 11, (no. 3), 2022.
[4] Pizzorni M. et al., International Journal of Adhesion and Adhesives, vol. 107, 2021.
[5] Parmiggiani A. et al., International Journal of Advanced Manufacturing Technology, vol. 114, (no. 7-8), pp. 2085-2101, 2021.

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