R&D IN HEALTH AT THE UPC

2023

Generalitat de Catalunya

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

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01 THE UPC

The Universitat Politècnica de Catalunya (UPC) is a public institution of research and higher education in the fields of engineering, architecture, sciences and technology, and one of the leading technical universities in Europe.

The UPC participates in the innovation system of Catalonia with projects and contracts for research, development, valorization of knowledge and commercialization of technology.

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RESEARCH, DEVELOPMENT AND INNOVATION ACTIVITY AT THE UPC IN 2022

141
Research groups

15
TECNIO research centers

305
PhD Thesis

€78,1 m
Project income

1.011
active R&D projects

2.526
Scientific journal articles

1.422
Contracts and agreements

13
Patents

6
New Spin-off UPC

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02 HEALTH

The World Health Organization (WHO) defines health as, *"the state of complete physical, mental and social well-being, not just the absence of medical conditions or diseases".*

In the field of research, development and innovation (R+D+I), there are several areas and disciplines related to the field of health.

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AREAS OF HEALTH TECHNOLOGIES

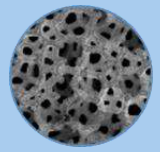
BIOINFORMATICS AND DATA PROCESSING

Bioinformatics is a discipline that lies between computer science, biomedical sciences, physics and chemistry.

It is a research area in which computer science and information technology are applied in the treatment of biological data.

Data processing responds to the need to analyze massive amounts of data generated by computational systems in order to translate the data into usable information.

BIOMECHANICS I BIOMATERIALS



Biomechanics, in science, is the study of the structure and function of biological systems using methods derived from classical mechanics, engineering, anatomy and physiology among other disciplines to solve problems in biological systems.

Biomaterials research is a multidisciplinary field that involves biology, materials science, chemistry, physics, engineering, medicine, and textile engineering in order for a material to interact with a biological system for a medical purpose.

INSTRUMENTATION, BIOMEDICAL SENSORS AND SIGNALS

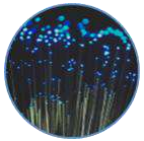
Biomedical instrumentation refers to all those measuring devices of any variable of interest in the field of biology that are used both to obtain information from signals produced by a biological system and to offer functional assistance or replacement of physiological functions.

On the other hand, **biomedical signals** are all those originating in a biological system that are used in the diagnosis or research of the system.

Finally, **sensors** are those devices used to detect the parameters of interest.

AREAS OF HEALTH TECHNOLOGIES

OPTICS, DOSIMETRY AND MEDICAL RADIATION



Research in **biomedical optics** focuses on the study, design and application of advanced optical techniques to solve problems in medicine and biology. Laser and optical techniques and technologies are included for basic biological research, as well as medical diagnosis and therapeutic applications.

Medical dosimetry is the determination, measurement and calculation of the radiation dose absorbed by a living organism, especially for diagnostic uses and the optimization of the delivery of radiation doses in medical examinations and treatments.

Medical radiation uses different forms of radiation to diagnose and treat certain medical conditions.

AUGMENTED/VIRTUAL REALITY AND IMAGE PROCESSING

Augmented reality is the ability to modify, improve and provide more information to reality by adding more elements through the technology that incorporates a device (i.e. GPS, digital camera, etc.).

Virtual reality is an artificial ecosystem (simulation) that is perceived as real and its goal is to replace the reality that surrounds us through device technology in order to perceive a world alien to the physical world (usually images are combined real with virtual).

Digital image processing is a method that applies digital techniques to an image in order to improve its quality, facilitate the search for information or extract useful information from it.

03

RESEARCH AND INNOVATION

Through the research groups distributed by its Schools and Faculties, the UPC has facilities and resources to provide its own services, in the areas of diagnosis, advice, development, demonstration, training and support to industry, the public sector and civil society in the promotion and deployment of health technologies.

Examples of activity I

Development of biomaterials for the regeneration and/or functional repair of tissues and organs.

Characterization of materials at a physicochemical and mechanical level and study of their interactions with biological entities at different levels - proteins, cells and tissues.

3D and 4D printing in tissue engineering and regeneration, using biodegradable and biocompatible cells and materials to print tissues and organs capable of responding to the characteristics of the environment.

Theoretical and experimental study of ionizing radiation and its applications, especially in the field of health.

Identification of **mechanical and chemical principles** underlying the behavior of **living materials** through theoretical and computational models.

Risk prediction modeling in the clinical setting, focusing on the joint analysis of **genetic and physiological signals** in several areas, such as cardiac risk assessment and depth of anesthesia assessment.

Exploration of new methods for the **interpretation** of clinically relevant information from **biomedical signals**.

Examples of activity II

Optimization of drug design with simulation and problem solving applied in fields such as HIV/AIDS, oncology, neurosciences, cardiology or immunology.

Improvement of **biomedical diagnosis** through **technologies based on light and machine learning**.

Study of new techniques and methods for the **intelligent control of robots** and application to specific areas such as fetal **surgery, laparoscopic and endoluminal surgery**.

Development of a potential treatment for incurable pediatric brain tumors.

Evaluation and monitoring through **multichannel biosignal processing** (electromyographic, electroencephalographic, etc.) and respiratory system analysis to improve rehabilitation processes.

Study of the structure and properties of **membrane receptor proteins**, functional enzymatic modification of **polymers and biopolymers** for biomedical applications, enzymatic synthesis and **polymerization and chemical and enzymatic modification of proteins.**

Reducing exposure to **nanoparticles** in industrial workplaces to improve worker health.

Examples of activity III

Development of robotic lower limb exoskeletons to assist spinal cord injured people.

Research of new paradigms related to **human movement,** mainly in the detection and **compensatory action of movement dysfunctions**.

Improvement and development of new **measurement methods for medical diagnosis, biotechnological processes** and the interaction of **electromagnetic fields** with **living beings.**

Creation of a portable system to monitor the evolution of biomechanical function in daily activities such as walking or climbing stairs in neurological patients.

Creation of a **valve for ventilation devices** that can be adapted to different characteristics of air flow and oxygen concentration.

Development of devices with **5G technology** in combination with **artificial vision and augmented reality** for people with reduced vision to improve mobility and accessibility.

Development of **intelligent templates** for carrying out **cardiovascular measurements.**

UPC RESEARCH GROUPS - HEALTH

- ANCORA - Heart rate analysis and control
- B2SLAB - Bioinformatics and biomedical signals laboratory
- BBT - Biomaterials, Biomechanics and Tissue Engineering
- BIOART - Biosignal analysis for rehabilitation and therapy
- BIOCOM-SC – Computational Biology and Complex Systems
- BIOMEC – Biomechanical Engineering Lab
- BIOSPIN - Biomedical signal processing and interpretation
- GBMI - Molecular and Industrial Biotechnology Group
- GOAPI - Applied Optics and Image Processing Group
- GPI - Image and Video Processing Group
- GRABI - Applied Research Group in Impact Biomechanics
- GRBIO - Biostatistics and Bioinformatics Research Group
- GRINS - Intelligent Robots and Systems
- IEB - Electronic and Biomedical Instrumentation
- IMEM-BRT- Innovation in Materials and Molecular Engineering - Biomaterials for Regenerative Therapies
- InSup - Surface Interaction in Bioengineering and Materials Science Research Group
- IONHE - Ionising Radiation, Health and Environment
- IRI - Institute of Robotics and Industrial Informatic
- ISI - Instrumentation, Sensors and Interfaces Group
- TOC - Community driven tecnology
- LACÀN - Numerical Methods for Applied Sciences and Engineering
- LAM - Multimedia Applications and ICTs Laboratory
- MICROTECH LAB - Microtechnology for the industry
- POL - Advanced Industrial Polymers and Technological Biopolymers
- RSP - Public Research Health Group
- VOS - Vision, Optometry and Health

SPECIFIC RESEARCH CENTERS

CD6 - Centre for Sensors, Instruments and Systems Development

The CD6 develops its activity in the field of optical engineering and photonics. Its activity is aimed at creating value through innovation.

CETpD - Technical Research Centre for Dependency Care and Autonomous Living

The CETpD focuses on the field of hardware - software technologies with the aim of contributing to the improvement of the quality of life of chronic patients, people with specific needs and/or with various degrees of dependence, such as, for example, with research of new paradigms related to human movement, mainly in the detection and compensatory action of movement dysfunctions.

CREB - Biomedical Engineering Research Centre

The CREB supports and promotes innovation and collaboration as well as excellence in research, study and training and is organized into seven research areas:

- Biomaterials;
- Biomedical signals and systems;
- Dosimetry and medical radiation;
- Computer graphics;
- Biomechanics;
- Robotics and vision;
- Instrumentation and e-health.

IDEAI-Intelligent Data Science & Artificial Intelligence Research Center

IDEAI-UPC is a research center with a certificate of consolidated research group of excellence recognized by AGAUR (SGR-1532), integrated by seven specialized research centers in the different branches of AI, with more than 80 researchers and full-time researchers, 72 permanent researchers and senior researchers and 150 PhD and master's students.

04

UPC EXCELLENCE PROJECTS

In this document are considered excellence projects those in which:

- The scientific process is rigorous and complex with high quality standards.
- They are strategic and tractors.
- They acquire a commitment to both social aspects and to great scientific and socioeconomic impact.
- They have repercussions on the territory.
- They comprise the different entities participating in the quadruple helix, so that the projects remain multidisciplinary.

The UPC excellence projects are financed by various programs, such as the State Plan or Horizon Europe.

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UPC EXCELLENCE PROJECTS

TAILOR - Design of personalized robotic and neuroprosthetic wearable systems for walking assistance using a predictive simulation framework

TAILOR project aims at developing a new generation of modular lower limb robotic exoskeletons and neuroprostheses that enable delivering of personalized, patient-specific technology for functional compensation of walking impairments caused by neurological conditions.

Furthermore, the technology developed will also have the capability of hybridation, where WR and NP are combined as a single device (hybrid robot, HR) for providing hybrid assistance of walking, optimizing the WR part while providing improved afferent input through the artificial stimulation of muscles.

Research group involved: BIOMEC

UPC EXCELLENCE PROJECTS

Pilot study to improve mobility and universal accessibility for visually impaired people in the city of Barcelona (BCN MOB)

Studies show that 40% of visually impaired people fall once a year and 63% of these falls have medical consequences. The fear of falling causes social isolation, a sedentary behavior and, consequently, a worsening of the quality of life, of the psychological state and of health in general, especially in the elderly, 10% of whom they can develop severe depression.

BCNMob wants to contribute to reversing this situation and aims to carry out a pilot study to analyze and measure the improvement of mobility and accessibility for people with visual impairments that can be achieved in the city of Barcelona. The study will be carried out through the development of devices with 5G technology in combination with artificial vision and augmented reality, integrated with Barcelona City Council's Open Data systems to inform users in real time.

Research group involved: Departament d'Òptica i Optometria

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UPC EXCELLENCE PROJECTS

3DSTAR - 3D Skin Tumor Analyzer

Skin cancer is a big problem from a social and economic point of view, representing the most common malignancy in caucasians. The first step of the clinical workflow for skin cancer care is the diagnosis of the lesion. The two gold standard methods used by the dermatologists to diagnose skin cancer are the naked eye examination following the ABCDE rule and the dermoscopy. However, due to the complexity of skin cancer, these methods still fail in a significant percentage of cases, with a mean sensitivity of 74% in the diagnosis of melanoma for the ABCDE examination by naked eye and 90% for dermoscopy.

In this project we propose a device with the capability of measuring the 3D shape of a lesion and characterizing 13 morphological parameters. In a clinical study already done by screening 600 skin suspicious lesions in the Hospital Clinic i Provincial de Barcelona (Spain) and in the University Hospital of Modena (Italy), the basic prototype of the 3D Skin Tumour Analyzer discriminated melanomas with a 91% of reliability and brought to the doctors new knowledge about the 3D shape of the lesion as no other commercial device can do.

Research group involved: CD6

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UPC EXCELLENCE PROJECTS

MV-Optimizer: A DIGITAL HEALTH SYSTEM FOR SAFE-PATIENT AND COST-EFFECTIVE MANAGEMENT OF MECHANICAL VENTILATION

MV-Optimizer integrates complex mathematical models that can dynamically train and self-adjust with patients' clinical data, giving clinicians the ability to test various ventilator configurations, simulating the patient's response to these configurations, and aiding decision-making.

Research group involved: department of Automatic Control

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UPC EXCELLENCE PROJECTS

MESURAR - Monitoring robotic walker users with mobility problems by means of werable sensors

The objective of this project is the development and validation of a monitoring system that provides continuous information of clinical utility on the state of the robotic walker user. This project proposes the use of wearable sensors in order to:

1. obtain information from the user on a continuous basis to adapt the control deployed in the walker to their needs;
2. provide useful information to clinicians on the evolution of the health status of users.

To this end, the wearable system will continuously monitor and evaluate the user based on the automatic estimation of different clinical scales. Movement parameters will be extracted, such as gait, balance and postural transitions parameters.

Research group involved: Technological Center of Vilanova i la Geltrú

UPC EXCELLENCE PROJECTS

CASPER

CASPER is a Cognitive Assistive Social Pet Robot. It will be primarily a robot designed for hospitalized children, having in mind a broader scope of scenarios, including caring environments, pedagogical units, educational institutions and home, for engaging particular parents-children interactions.

Hence, it will be developed with the aim to cover three social services to:

1. Reduce pain and anxiety in children when they are submitted to some intervention, preferably in short-term interaction and regular interventions with chronic diseases;
2. Increase engagement in the children – institution – parents network in very stressful situations (oncology unit, recovery unit, social conflicts);
3. Engage children in educational treatments from several perspectives (social skills with autistic children, healthy meals with anorexic children, meal recommendations and drug delivery with diabetic children).

Research group involved: IDEAI

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UPC EXCELLENCE PROJECTS

RemPark - Personal Health Device for the Remote and Autonomous Management of Parkinson's Disease

The CETpD has developed a pioneering portable monitoring and performance system to identify in real time the motor status of people with Parkinson's. The system also assesses what phase the patient is in while walking or during daily activities and acts when the person suffers walking difficulties such as slowing or blocking.

Research group involved: CETpD

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Some articles

Pareto, J. (2022). Robótica social asistencial. Implicaciones y desafíos éticos. Brains (Barcelona) Vol. 2 num. 2 p. 39-43 https://upcommons.upc.edu/handle/2117/380764

The paper presents new techniques for the design, simulation, sensing and control of rehabilitation devices for rehabilitation devices such as motorized exoskeletons, neuroprostheses and equipment to move the rehabilitation environment out of the clinical setting.

Rajasekaran, V. (2015). Adaptive Control for Wearable Robots in Human-Centered Rehabilitation Tasks. http://hdl.handle.net/2117/96044

The article presents an adaptive strategy for on-demand assistance, which adjusts to the specific needs of the patient along with input from the therapist whenever necessary.

Urdiales, C.; Peula, J.; Barrue, C.; Pérez, EJ.; Sánchez-Tato, I.; del Toro, J.; Cortes, U.; Sandoval, F.; Annicchiarico, R.; Caltagirone, C. (2018). A new collaborative shared control strategy for continuous elder/robot assisted navigation. (pg. 1-5) https://upcommons.upc.edu/handle/2117/15671

The article proposes a method that allows constant cooperation between humans and robots, having tested the proposed method on a robotic Meyra wheelchair at the Santa Lucia Hospedale in Rome with several volunteer hospitalized patients with different disabilities.

Carmona, V.; Lobo, J.; van Ruysevelt, J.; Torras, C.; Font, J.M. (2020). Development and pilot evaluation of the ArmTracker: a wearable system to monitor arm kinematics during daily life. p. 759-764 https://ieeexplore.ieee.org/document/9224302/

05 EDUCATION

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BACHELOR'S DEGREES

- Bachelor's degree in Biomedical Engineering (EEBE)
- Bachelor's degree in Optics and Optometry (FOOT)
- Bachelor's degree in Biosystems Engineering (EEABB)
- Bachelor's degree in Food Engineering (EEABB)
- Bachelor's degree in Culinary and Gastronomic Sciences (interuniversity UB-UPC degree) (EEABB)
- Bachelor's degree in Industrial Electronics and Automatic Control Engineering (EEBE, EPSEM, EPSEVG, ESEIAAT)
- Bachelor's degree in Bioinformatics (interuniversitary UPF-UPC-UB-UAB) (FIB)
- Bachelor's degree in Informatics Engineering (FIB, EPSEVG)
- Bachelor's degree in Artificial Intelligence (FIB)

MASTER'S DEGREES

- Erasmus Mundus master's degree in Bio and Pharmaceutical Materials Science (BIOPHAM)
- Master's degree in Biomedical Engineering
- Master's degree in Neuroengineering and Rehabilitation
- Master's degree in Optometry and Vision Sciences
- Master's degree in Biomedical Data Science
- Master's degree in Occupational Health and Safety
- Master's degree in Enabling Technologies for the Food and Bioprocessing Industry (TECH4AGRI+FOOD)
- Master's degree in Chemical Engineering
- Master's degree in Informatics Engineering
- Master's degree in Artificial Intelligence
- Master's degree in Automatic Control and Robotics

DOCTORAL PROGRAMMES

- Optical Engineering
- Photonics
- Agri-food Technology and Biotechnology
- Statistics and Operations Research
- Biomedical Engineering
- Bioinformatics
- Artificial Intelligence
- Automatic Control, Robotics and Vision

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Més màsters: https://www.upc.edu/ca/masters
Més programes de doctorat: https://doctorat.upc.edu/ca/programes/

UPC-SCHOOL

- Master's degree in Optometry and Visual Therapy
- Master's degree in Pediatric Optometry
- Postgraduate in Digital Health Leadership
- Postgraduate in Architectural Design for Hospital Projects

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