Abstract

Advanced computing paradigms are essential to extend the frontiers of our ability to process information in many sectors of society. On this theme, the Center aims at promoting research, education and relationships with industry, by integrating and sharing experiences of different disciplines with a strong computational component.

Scientifically, the Center pursues the investigation of architectural and algorithmic paradigms from the general perspective of computer science, as well as the application of such paradigms to problems arising in the computational disciplines. Current research takes place within the following domains: Astronomy and Astrophysics, Bioengineering, Physics, Electrical Engineering, Structural and Material Engineering, Computer Science.

The Center operates as a network of research groups, dynamically growing with the expanding of computational interests in various sectors of the University and with the development of specific collaboration opportunities.

Keywords

- Computational Science
- Computer Engineering
- Algorithms
- Computer Architectures
- High-Performance Computing

Electrical Engineering

EE adopts the computational approach to solve, via simulation, magneto-hydro-dynamics and electro-thermal problems that impact a number of industrial processes.

EE investigates:
- magneto-hydro-dynamic problems that arise in the electromagnetic processing of materials (e.g., for photovoltaic silicon or aerospace materials);
- electromagnetic and thermal coupled problems in induction heating (relevant, e.g., in the hardening of metal parts).

Astronomy and Astrophysics

A&A apply the computational approach to the processing of the massive amount of data received from state-of-the-art telescopes, and to the exploration of the structure and the history of the universe at various scales.

A&A:
- simulate galaxy formation and evolution;
- simulate the cosmic background radiation;
- simulate the interstellar medium (dark matter);
- develop high-performance data acquisition, storage, and analysis pipelines suited to extremely large telescopes and detectors that generate terabytes of data each night;
- study orbit determination for satellites and gravitational field estimation in the Solar System.

Computer Science

CS provides the architectural and algorithmic methodologies that are mandatory to harness the computational power available to researchers:
- choice of the algorithmic framework that is most appropriate for the scientific/engineering problem at hand;
- high-level algorithm design and optimization;
- software implementation and optimization.

CS investigates efficient algorithms for common computational problems: solution of sparse linear systems, differential equations, etc.

CS researches novel methodologies for the design of high-performance algorithms and architectures.

Bioengineering

BIOE applies the computational approach to the processing of functional imaging data, and to the investigation of gene/protein regulatory networks.

BIOE studies:
- pre-processing and data-mining techniques for high-throughput genomic and proteomic data sources;
- techniques to infer gene/protein regulatory networks;
- quantitative image analysis methods for PET and MRI.

BIOE integrates different brain signals (EEG, MEG, imaging (fMRI, DTI, ASL)) approaches and advanced nonlinear data-driven methods to determine functional brain connectivity maps.

Structural and Material Engineering

SME applies the computational approach to the solution of multi-scale, multiphysics problems crucial in nuclear, civil and environmental engineering.

SME simulates:
- fire in tall buildings and tunnels;
- the evolution of thermo-chemo-mechanical processes in cementitious and ceramic materials;
- landslide initiation and propagation; land subsidence;
- the long-term behavior of nuclear waste disposals.

SME analyzes thermo-mechanical and electro-mechanical problems in thermo-nuclear fusion technology (e.g., strain field and related critical current of ITER coils, performance of superconducting magnets).