“Mathematical theory for control and optimization of evolutionary phenomena”

Research theme title: Mathematical theory for control and optimization of evolutionary phenomena.

Contacts:
Prof. Andrea Pinamonti e-mail: andrea.pinamonti@unitn.it
Prof. Fabio Bagagiolo e-mail: fabio.bagagiolo@unitn.it

Curriculum of DAUSY: C1 AS for Automation

Hosting University/Research Centre
University of Trento, Italy
Department of Mathematics,
Via Sommarive, 14, 38123 Povo-Trento, Italy
https://www.maths.unitn.it/en

Prospective Supervisors:
Prof. Andrea Pinamonti (https://webapps.unitn.it/du/it/Persona/PER0015797)
Prof. Fabio Bagagiolo (https://bagagiolo.maths.unitn.it/index.html/)

Description:
The goal of the present project is the study, the application and the development of mathematical theories for control and optimization of evolutionary phenomena motivated by engineering and real life applications. The typical differential equations for the evolution of the system under study can be often seen as describing evolution in an abstract environment such as functional and/or metric spaces. Such a point of view brings to important questions of mathematical nature which are also often enlightening for the possible applications to the motivating real-life models. Problems such as controllability, optimal control, optimal transport, motion planning will be the main examples of sources of mathematical questions and motivating applications.
The doctoral student will be asked to investigate, from a mathematical point of view, problems among the following (not exhaustive) list:

- controllability, optimal control and/or dynamic games for multi-agent systems;
- hybrid systems (continuous and discrete systems, in particular dynamic programming and Hamilton-Jacobi theory);
- systems with hysteresis (evolving systems with suitable dependence on the past history of the evolution itself);
- geometric control theory with particular emphasis to the applications to nonholonomic path planning of mobile robots.

The strong interaction with scientists of more applicative fields will be also a valuable point of the research activity of the student.

Specific Information:
Applicants must hold a master’s degree, preferably in Mathematics, with a good background in some of the relevant areas of interest and of the related mathematical tools, such as: control, optimal control, optimal transport, calculus of variations, differential equations theory, functional analysis, analysis on metric spaces, measure theory. Numerical methods expertise will be also welcome. Proficiency in both spoken and written English is required. The candidate should be highly

motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and possible applications.

References:
[1]. Bardi M., Capuzzo Dolcetta I.: Optimal Control and Viscosity Solutions of Hamilton-Jacobi-Bellman Equations. Birkhauser, 1997.
[2]. Cardaliaguet, P.: Notes on Mean Field Games. Lecture notes (from P.-L. Lions' lectures at College de France), 2013.
[3]. Coron J.M.: Control and Nonlinearity, AMS, Providence, 2007.
[4]. Goebel R., Sanfelice R.G., and Teel A.R.: Hybrid Dynamical Systems: Modeling, Stability, and Robustness, Princeton University Press, Princeton, 2012.
[5]. Latombe J-C: Robot Motion Planning, Kluwer Academic Publishers, Boston, 1991.
[6]. Laumond J-P: Robot Motion Planning and Control, Lecture Notes in Control and Information Sciences, Vol. 229, Springer, 1998.
[7]. Reeds JA, Shepp LA, Optimal paths for a car that goes both forwards and backwards, Pacific Journal of Mathematics, 145, (1990), 367-393.
[8]. Sussmann HJ, Tang G: Shortest Paths For The Reeds-Shepp Car: A Worked Out Example Of The Use Of Geometric Techniques In Nonlinear Optimal Control, Department of Mathematics, Rutgers University, September, 1991, Report No.:SYCON-91-10.
[9]. Visintin A.: Differential Models of Hysteresis, Springer Verlag, Berlin, 1994.

Type of scholarship:
DM 118/2023 – Project on PNRR (Italy's Recovery and Resilience Plan)

Study and research period outside the Hosting Institution:
LJLL - Laboratoire Jacques-Louis Lions, Sorbonne université Boîte courrier 187, 4 place Jussieu, 75252 Paris Cedex 05 (France)
6 months