LAGEPP – UMR 5007
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Laboratoire
d'automatique,
de génie des procédés
et de génie pharmaceutique

Ph.D. Position:
« Infinite-dimensional internal model regulators for finite-dimensional nonlinear systems »

Location: UCBL1 http://www.univ-lyon1.fr/
Lab: LAGEPP http://www.lagep.univ-lyon1.fr

Main advisor: Daniele Astolfi (CNRS - LAGEPP)

Scientific Domain: Control theory, mathematics, dynamical system, engineering.

Objectives, scientific challenges and expected original contributions: The problem of rejecting constant disturbances while following references is a central issue in control theory. It is also known as *robust output regulation problem*, and it arises in most control feedback applications, from engineering, to neuroscience [1]. For controlled plants described by linear dynamics, such a problem has been solved in the 70's by means of the celebrated *internal-model principle* [1] claiming that asymptotic output regulation can be achieved robustly with respect to parametric uncertainties only if the regulator replicates a suitable copy of the dynamical model generating the disturbances or references [5, Section 3]. For constant signals, this consists in using an integral action in the feedback-loop. In the context of nonlinear systems, no general theory is available, although research is still active in this domain [2]. The objective of this project is to study the robust output regulation problem of finite-dimensional nonlinear systems by means of infinite-dimensional internal model controllers, providing an exhaustive solution to such a fundamental problem that has been open for more than 50 years. Following the celebrated internal model principle, we aim at developing the theory of infinite-dimensional regulators by means of conservative and dissipative operators, following the preliminary ideas developed in [3]. During the project, we aim also at developing new tools for the stabilization of interconnections of PDE and (nonlinear) ODEs [4] and at studying the finite dimensional realization of the proposed regulators for practical implementation purposes [5]. The control problem of heat exchanger networks will be used as a pilot test for experimental validations of the proposed methodology [6].

Length and remuneration of the Ph.D.: 36 months with a salary of around 1500€ net per month, to be started between September 2023 and November 2023. The salary can be increased by around 200€ net per month by teaching (bachelor/master's degree level) around 60 hours per year. For teaching, the French language is usually needed.

Candidate profile:
We are looking for self-motivated team-player candidates that match the following profile:
- A Master's degree in Control Systems, Mathematics, Mechatronics or Dynamic Systems-related disciplines with excellent grades;
- Excellent academic records, solid mathematical background, excellent knowledge in dynamic systems; good computer programming skills are a plus but not mandatory.
- Excellent oral and written communication skills;
- English language mastery (writing and presenting) is mandatory.
- French language is a plus, but not mandatory

Eligibility criteria:
Applicants must fulfill the following eligibility criteria:
- At the time of the application, applicants must be in possession or finalizing their Master's degree or equivalent/postgraduate degree;
- At the time of recruitment, applicants must be in possession of their Master's degree or equivalent/postgraduate degree which would formally entitle them to embark on a doctorate.

Application:
All applications should be compressed (.zip, 5MB max.) and submitted by email to the addresses

daniele.astolfi [at] univ-lyon1.fr

with the title

PhD application 2023 (project Alligator): name surname

including:

- Cover letter including a statement of purpose and previous experiences;
- Detailed curriculum vitae;
- Course grades transcripts;
- A scientific writing sample (Master thesis, seminar paper, or equivalent);
- Contact information of two references.

For more information concerning this position, please contact:

Daniele Astolfi
daniele.astolfi [at] univ-lyon1.fr

References :
[1] M. Bin, J. Huang, A. Isidori, L. Marconi, M. Mischiati, E. Sontag, Internal Models in Control, Bioengineering, and Neuroscience, *Annual Review of Control, Robotics, and Autonomous Systems* vol. 5, pp. 55-79.
[2] M. Bin, **D. Astolfi** and L. Marconi, About Robustness of Control Systems Embedding an Internal Model, *IEEE Transactions on Automatic Control*, March 2023.
[3] **D. Astolfi**, S. Marx, and N. van de Wouw, Repetitive control design based on forwarding for nonlinear minimum-phase systems, *Automatica*, vol. 129, 109671, July 2021.
[4] S. Marx, L. Brivadis and **D. Astolfi**, Forwarding techniques for the global stabilization of dissipative infinite-dimensional systems coupled with an ODE, *Mathematics of Control, Signals, and*

Systems, vol. 33 (12), pp. 755-774, December 2021.
[5] **D. Astolfi**, L. Praly and L. Marconi, Harmonic Internal Models for Structurally Robust Periodic Output Regulation, *System & Control Letters*, vol. 161, 105154, March 2022.
[6] B. Zitte, B. Hamroun, **D. Astolfi** and F. Couenne, Robust Control of a Class of Bilinear Systems by Forwarding: Application to Counter Current Heat Exchanger, 21st IFAC 2020 World Congress, Berlin, Germany, July 2020.