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Laboratoire
d'automatique,
de génie des procédés
et de génie pharmaceutique

Research Internship:
« Integral action for non-uniformly observable systems »

To apply : Submit your CV and a motivation letter to: daniele.astolfi@univ-lyon1.fr

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

Advisors of the stage: Daniele Astolfi (CNRS LAGEPP), Vincent Andrieu (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 set-point references is a central issue in control theory. This problem is typically addressed by means of PI (proportional-integral) controllers, which are used from theory to real-life applications. However, the use of PI for complex nonlinear systems is difficult in general, and yet no general theory is available, although research is still active in this domain (e.g. [1]). The use of PI controllers is particularly difficult when the full state is needed to design a feedback stabilizer, but the full-state is not available, i.e. directly measurable. This is typically the case of variables which cannot directly be measured because a sensor doesn't exist or sensors are expensive or cannot be implemented because of technological issues. As a few example, one can think about the state of the charge of a battery (a sensor giving such an information doesn't exist!), the speed of a drone (typically, only position through GPS and acceleration via accelerometers are known), or the case of a sensorless electrical motor (where sensors are not used to reduce costs). In these cases, a common strategy is to use a state-feedback law and then substitute the state by an estimate provided by a digital sensor, i.e. an observer [2]. Unfortunately the combination of these two elements is not guaranteed to work and detailed analysis is needed, especially in case of non-uniform observability properties. Recent results show that for certain classes of nonlinear systems, relevant for real-life applications, output-feedback laws can be designed [3]. The objective of this stage is to study therefore the use of integral action for systems which are described by non-linear dynamics and may be non-uniformly observable. This work will be then applied to the case of control of heat exchangers [4].

Internship organization: In the first part of the internship, the student will read and develop a new theoretical tool to design an integral action output-feedback law for non-uniformly observable systems. The aim is to find some sufficient conditions on the model to allow the design of such an algorithm. In a second step, this theory will be applied in simulation on the case study of heat exchangers.

Length and remuneration of the stage: 5 to 6 months with a salary of 550€ net per month, to be effectuated between January 2023 and September 2023.

Application and expected profile: We look for a candidate with a strong background in math and or control theory. Special priority will be given to candidates willing to try a first experience of research to be continued towards a research career to be developed in the context of a PhD thesis on related topics. A PhD grant on own funding (ANR) is available.

References :

[1] M. Giaccagli, **D. Astolfi**, V. Andrieu and L. Marconi (2022). Sufficient Conditions for Global Integral Action via Incremental Forwarding for Input-Affine Nonlinear Systems, IEEE Transactions on Automatic Control.

[2] P. Bernard, V. Andrieu and **D. Astolfi** (2022). Observer design for continuous-time nonlinear systems, *Annual Reviews in Control*, 53, 224-248.

[3] L. Sacchelli, L. Brivadis, V. Andrieu, U. Serres, U. and J.P. Gauthier, (2020). Dynamic output feedback stabilization of non-uniformly observable dissipative systems. IFAC-PapersOnLine, 53(2), 4923-4928.

[4] B. Zitte, B. Hamroun, D. Astolfi, and F. Couenne (2020). Robust control of a class of bilinear systems by forwarding: Application to counter current heat exchanger. IFAC-PapersOnLine, 53(2), 11515-11520.