Implicit discretization and sliding mode control for infinite-dimensional systems

Research Context. The general context of this internship is the study of the stabilization and the numerical discretization of infinite-dimensional systems subject to disturbances. It is well known nowadays that many physical phenomena can be modeled with infinite-dimensional systems. However, controlling them is still a challenge, and it is even more difficult when taking into account perturbations. Indeed, if many techniques are known for the stabilization of partial differential equations [5, 2] (mainly, linear ones), the case where such systems are subject to disturbances (due to error in the model or to external unknown forces) has not been tackled yet in an exhaustive fashion. However, we may mention [1], where a systematic sliding mode methodology is proposed for a class of linear infinite-dimensional systems. The implementation of such controllers is even more a challenge in the infinite-dimensional context.

Goals. The goal of this internship is to focus on some specific classes of PDEs, namely the transport equations [2]. Our general strategy relies on the sliding mode control methodology [4] and can be seen as follows: first, we discretize in space an infinite-dimensional system, leading to a high-dimensional system for which a sliding mode controller will be designed; second, an implicit Euler discretization should be planned, together with convergence guarantees [3]; third, the designed control has to be tested on the non-discretized system.

Working Context. The internship will be advised by Swann MARX (CR CNRS, LS2N), Clément Moreau and Franck Plestan, and funded by the ANR project SLIMDISC - a salary of 659,76 euros/month, brut. The Master student will be hosted by the CODEX team in the LS2N laboratory, located in Centrale Nantes, but possible collaborations with other members of the ANR (from INRIA Grenoble or INRIA Lille) can be planned.

Required Skills. Motivated candidates should hold a Bachelor degree and have a solid background in **either** partial differential equations, control and numerical schemes. Good programming skills are also required. The candidates are kindly asked to send an e-mail with "M2 candidate" in the title, a CV and motivation letter to `swann.marx@ls2n.fr` and `clement.moreau@ls2n.fr`. Knowledge of French does not constitute a prerequisite.

A related PhD topic can be foreseen. Motivated candidates can contact us if they want to start the Phd without doing the internship.

References

[1] I. Balogoun, S. Marx and F. Plestan. Sliding mode control for a class of linear infinite-dimensional systems arXiv preprint arXiv:2210.13465, 2022.

[2] G. Bastin and J.M. Coron. Stability and boundary stabilization of 1-D hyperbolic systems Basel: Birkhäuser (Vol. 88), 2016.

[3] B. Brogliato and A. Polyakov. Digital implementation of sliding-mode control via the implicit method: A tutorial. International Journal of Robust and Nonlinear Control, 31(9), 3528-3586, 2021.

[4] Y. Shtessel, C. Edwards, L. Fridman and A. Levant. Sliding Mode Control and Observation. Basel: Birkhauser, 2014.

[5] R. Vazquez, J. Auriol, F. Bribiesca-Argomedo and M. Krstic. Backstepping for Partial Differential Equations, arXiv preprint arXiv:2410.15146, 2024.