

Master internship proposal

Observer Design for Nonlinear Systems via Time-Scaling



Subject: Observer Design for Nonlinear Systems with Unknown Parameters via Regular and Singular Time-Scaling

Student profile: Master student or final year of an engineering school (bac+5), with experience in mathematical modelling, control theory, and Matlab/Simulink.

Salary: 500-600 €, according to the working days of the month (minimum statutory allowance applicable in public institutions).

Work place: L2S, CentraleSupélec, 3 rue Joliot Curie, 91190 Gif-sur-Yvette, France.

Keywords: Observers, nonlinear control, systems with unknown parameters, simulations.

Employer: CentraleSupélec. Legal status: Public engineering school (Grand Établissement); Member of Université Paris-Saclay.

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Context

In many dynamical systems, the variables that can be directly measured with physical sensors are not necessarily the variables of interest for monitoring, diagnosis, or control. Software-based reconstruction of unmeasured states and parameters can therefore provide a valuable complement to physical measurements. An observer can be viewed as a software sensor: it consists of a dynamical model of the system coupled with measured outputs through suitable correction terms, with the objective of making the observer synchronize asymptotically with the actual system.

A specific approach was proposed in [1], to construct observers for a particular class of nonlinear systems. It addresses systems for which the error dynamics can be linearized after a regular or singular time-scaling. This method relies on a switching observer that combines different observer dynamics depending on the operating region of the system. This approach makes it possible to construct observers for systems for which standard observer-design techniques may not be directly applicable.

The objective of this internship is to investigate extensions of this methodology and to assess its applicability to more complex nonlinear systems, in particular to systems with unknown parameters.

Objectives:

The internship will focus on the design and analysis of observers based on regular and singular time-scaling. The work will be organized around the following objectives:

1. **Study of the existing methodology.** The student will first review the theory of nonlinear observers, asymptotic stability of observation errors and time-scale transformations. For instance, the observer proposed in [1, 2] will be implemented and tested on some representative nonlinear systems.
2. **Extension to more general systems.** Then, the student will study an observer approach based on least-squares identification [3], applied to a representation of the system in a new time scale. Particular attention will be paid to the inversion of the time transformation, which is required to recover the system state in the original time scale. This work will serve as a starting point for investigating more advanced observer designs, in particular the switching observer proposed in [1, 2], and for extending the time-scaling approach to nonlinear systems with unknown or uncertain parameters.

3. **Numerical validation.** The proposed methods will be implemented in MATLAB/Simulink and compared with existing observer techniques. Numerical experiments will be conducted on one or more applications, potentially including automotive systems, electromechanical systems, or biological processes.



Contacts

Please send a CV and a motivation letter to:

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with object [Stage Observers]

The position is available immediately and applications will be accepted until this position is filled. A National Security clearance is needed, and it can require approximately 2 months.

References

- [1] Hoang, T. B., Pasillas-Lépine, W., and Respondek, W (2014). A switching observer for systems with linearizable error dynamics via singular time-scaling. In MTNS 2014.
- [2] Aguado-Rojas, M., Hoang, T. B., Pasillas-Lépine, W., Loria, A., Respondek, W. (2021). A switching observer for a class of nonuniformly observable systems via singular time-rescaling. IEEE Transactions on Automatic Control, 66(12), 6071-6076.
- [3] Ling, K. V., Wu, X. J., Lim, K. W. (1996). State observers for single rate and multirate controllers. IFAC Proceedings Volumes, 29(1), 1321-1326.