Master M2 research internship subject proposition

How to choose well the data collection experiment in order to get an accurate model of the system dynamics for control purposes ?

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Keywords: data-driven modeling, system identification, dynamical systems, data informativity.

Topic: Optimal control requires exact knowledge of the system dynamics under consideration, which are often unknown. By collecting data on the system with an excitation defined by the user, a model of the system dynamics can be estimated, and then a controller can be designed based on this model. This is the principle of system identification for control. However, the data are often noisy, leading to uncertainties which the degrade control performances. Increasing the amount of data can reduce these uncertainties. However, this is only possible if a fundamental property is guaranteed: data informativity.

Data informativity ensures that the collected data carry sufficient information about the system dynamics in order to identify a unique model. Otherwise, ambiguity arises and several models explain the data equally well. System identification algorithms can then return an absurd model. This can become extremely dangerous if a controller is subsequently synthesized from this model since instabilities may occur. Some studies have linked data informativity to the persistency of excitation [6, 7, 5, 4, 2, 3, 1], but most of these studies rely on asymptotic assumptions [6, 5, 4, 2, 3, 1] or on the assumption of noise-free data [7], which is unrealistic for real-life systems. The scientific challenge of this M2 Master internship project is to develop methods to verify the data informativity from a **finite number** of noisy data points.

This challenge will be studied theoretically for linear time-invariant systems with control techniques such as linear quadratic adaptive control, quadratic predictive control, etc. Methods for verifying data informativity will also be developed. For the analysis of data informativity, the novel approach followed in [4, 2] seems very promising as it can also be applied in the case of a finite number of data points. Another strategy to consider is to model the noise in a non-parametric way as proposed in [7] for noise-free system dynamics.

Duration: April 2025 - September 2025 (6 months)

Location: CRAN, Polytech site, 2 rue Jean Lamour, 54514 Vandoeuvre cedex, France

Desired Profile: We are looking for an M2 Master student in control engineering, machine learning, or applied mathematics who **wants to do a PhD after this internship at CRAN**. The chosen candidate will then be presented for the doctoral competition at the University of Lorraine in order to get a funding. A good level in English is required; knowledge of French is not obligatory.

References

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