PhD position proposal

Title :

Systems inversion : Applications in control and observation problems

Laboratory : Laboratoire Ampère UMR CNRS 5005 (http://www.ampere-lab.fr)
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Keywords :
Control theory, inversion, feedforward, input reconstruction, observer with unknown input, disturbance attenuation

Context :
This PhD position will be supervised by W. Marquis-Favre, M. Di Loreto and V. Léchappé, and will be realized at Laboratoire Ampère, INSA de Lyon. This thesis is concerned with inversion methods for dynamical systems. It aims to develop new and original methods for input reconstruction in linear (and non linear) systems, and to validate these methods on control problems and experimental benchmarks.

Description :

Control theory aims to develop tools and methods for the analysis, design and control of dynamical systems. A central problem in control theory is concerned with the inversion of dynamical systems, namely how to retrieve inputs of a given system when specifications on outputs are known [1,2,3]. Inversion of models is used in a wide variety of problems, as for instance in the design of feedforward control, motion planning or in feedback control, with applications in disturbance attenuation for physical systems, output regulation, parameters identification, image processing or trajectory planning in robotics, to cite a few. Inversion is in general not well-posed, with an high sensitivity to measurements, and exhibits intrinsic difficulties for an on-line realization, since inversion is non causal, in general.

The aim of this thesis is to contribute to the development of algorithms for the inversion of dynamical systems. The methods to be developed need to be causal with a state-space realization for practical implementation, and have to ensure a compromise among robustness against uncertainties in the model [4], performances for input reconstruction and numerical computations. These methods will be based on regularization techniques [5], which are well known in inverse problems, and observer theory (with unknown inputs) [6].

These algorithms will be developed in the case of linear multivariable time-invariant (LTI) systems. These algorithms will be a starting point for future research directions. These directions include two main aspects. The first one is to revisit a number of control problems, like feedback control as an approximate inversion problem [7], output regulation with internal model for disturbance rejection, parameters (coefficients in the model or input delay) identification, or continuous-time input reconstruction from discrete-time output measurements. The second aspect is concerned with applicative problems, where the developed methods should be applied to prove their feasibility and potentiality. A wide variety of applications can be addressed in Laboratoire Ampère, and will depend mostly of the background and interest of the PhD student.

Finally, extensions of these methods to nonlinear models will be investigated as a challenging topic.

This thesis allows to contribute to the field of Control Theory and will give to the PhD candidate a large viewpoint and expertise on a wide variety of problems and applications.

The thesis will be realized in a research laboratory of an Engineering school being well known actor of high quality of its education, applied and fundamental research. It allows the candidate to make a real opportunity for both academic research career or research engineer career in industry.

Requirements :

This PhD position is in the domain of Automatic and control theory. Scientific requirements are basic knowledge of control theory, Applied Mathematics, Numerical simulation, and engineering sciences.

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