Ecole Centrale de Lyon - INSA de Lyon – Université Claude Bernard Lyon 1
Laboratoire Ampère
Unité Mixte de Recherche du CNRS - UMR 5005
Génie Electrique, Electromagnétisme, Automatique, Microbiologie environnementale et Applications

PhD Thesis on
Identification for control: from local to global performance

Laboratory: Ampère UMR CNRS 5005, Ecole Centrale de Lyon, Ecully, France

Scientific field: Systems and Control

Keywords: Interconnected systems, System Identification, Robust Control, Decentralized Control

Supervisors

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Scientific context

Most of modern engineering systems are interconnected. The interconnections raise a challenging issue for the systematic design and maintenance of these systems. This is fully recognized by the research theme ''large-scale interconnected systems'' of the Ampère Laboratory. The proposed PhD project aims to develop a joint identification and control methodology to appropriately model and control these interconnected systems in order to guarantee high performance both at the local and global levels. The developed methods find applications in different fields such as the control of complex mechatronics systems and the synchronization of clocks (investigated by the research team).

General objectives of the PhD thesis and expected scientific contributions

System identification is an efficient technique to deduce, using data collected on the real-life system, an accurate model of the system and to evaluate its uncertainty. This uncertain model can subsequently be used to design a robust controller for the system at stake. It is important to note, on the one hand, that to achieve a certain level of performance the uncertainty of the model must be limited and, on the other hand, that the uncertainty of the identified model highly depends on the richness of the data collected during the identification process. Our team has therefore developed methodologies that efficiently connect the identification and robust control steps by optimally designing the identification experiment in such a way that the uncertainty of the identified model is small enough to enable satisfactory robust control [1,2]. We have applied this philosophy for various domains of applications, e.g. for the design of feedback controllers for industrial processes in the EU-FP7 project Autoprofit [3], for the monitoring of electrical transmissions systems [4] and for the design of feedforward actuation for mechatronics systems [5].

Until now, we have considered the case of isolated control systems. However, in modern engineering, control systems become more and more interconnected (i.e. formation control of drones/satellites, automated highway systems, clock synchronization via PLL networks in computer systems). In these types of systems, the reference of the individual control systems is computed based on the measurements of the output of the neighboring control systems. Due to this interconnection, the uncertainty in each system has influence on the performance of the other systems in the network. Moreover, as far as identification is concerned, excitation signals and perturbation signals related to one individual loop have also influence on each of the other loops in the network.

The identification of individual modules in an interconnected system has been investigated in our research team since a couple of years. We have first investigated the fundamental question of determining the minimal conditions under which a module is identifiable [6,7,8]. In this PhD project, our first aim is to consider the even more challenging questions of experiment design and uncertainty quantification in such networked systems. We will consider the following research questions. What are the optimal location(s) in the network to apply the excitation signal(s)? How can we evaluate the model uncertainty in each of the individual module taking into account the influence of each excitation signal and the perturbations acting on all systems in the network? Can perturbations in one module reduce the level of excitation needed to obtain a certain accuracy in another one?

Building on these identification issues, we will also consider the challenging problem in *identification for control* of being able to obtain models of the individual modules which will allow to design model-based controllers achieving satisfactory performance not only on each of the module taken individually (local performance), but also at the global level i.e. for the interconnection of all closed-loop systems. For this purpose, we will use our identification results to optimally design an identification experiment leading to models of each individual module with a sufficiently small uncertainty to guarantee both a satisfactory local and a satisfactory global performance. This problem can be tackled in two subsequent steps: 1) the determination of a maximal admissible uncertainty for each module and 2) the design of the excitation signal(s) that have to be applied to the network to obtain an identified model with an uncertainty smaller than the admissible one. This part of the research project builds upon our previous work on optimal input design for control [1,2] and robust control of interconnected systems [9,10,11]. This project will also benefit from the longstanding collaboration between the research team and the automatic control group in Stockholm (see e.g. [2,3]).

Research program

Three fundamental work packages will be considered in this project:
1) Experiment design and model uncertainty quantification for network identification
2) Determination of the maximum allowable uncertainty for interconnected systems
3) Design of optimal excitation signals for the control of interconnected systems
The developed techniques will be first tested on some simple academic examples. As a second step, a more sophisticated model associated to a network of PLL [9] will be considered. Real-life experiments on such a typical network constitute the final objective.

What do we ask?

We are looking for a candidate with an MSc degree in Systems and Control, Electrical or Mechanical Engineering. A specialization in Systems and Control is an asset. The candidate must have strong analytical and communication skills. A very good command of the English and/or French language is required.

How to apply?

Submit you application before 25 April 2016 to the supervisors (xavier.bombois@ec-lyon.fr and anton.korniienko@ec-lyon.fr). Include a cover letter along with a detailed curriculum vitae, a separate motivation letter stating why the proposed research topic interests you, electronic copies of the MSc and BSc grades and eventual reference letters. The project is expected to start on 01/10/16.

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