Open PhD Position in Automatic Control - 2020

Contract: Public service (CDD)
Required Diploma: Master degree
Position: Ph D
Ecole: Centrale Lille
Laboratory: CRIStAL UMR 9189 CNRS – Centrale Lille – University of Lille
Web site: https://www.cristal.univ-lille.fr
Name of the supervisors: PERRUQUETTI Wilfrid & ESPITIA HOYOS Nicolas
Duration : 36 months, starting the 1st of October, 2020
Monthly gross /net salary: between 1800/2100 € / between 1400/1700 € (including Social security coverage)

Title: **Finite-time control and estimation of some classes of PDEs**

Context:

Internet of Things (IoT) is already surrounding us with its new challenges. One of them being related to the complexity. How to manage complexity of our hyperconnected world? Our research group aims at developing a new **control/estimation framework for taming complexity of large scale connected systems.** Complex hyperconnected systems are made of different subsystems, described by dynamical models and/or logical models or sometimes without any known mathematical dynamical model. Here, we will focus on **dynamical models** such as ordinary differential equations (ODEs), time-delay systems (TDS), partial differential equations (PDEs).

Regarding stability issues for interconnected dynamical systems, it is well-known that connecting two stable systems may not result in a stable one, even if both systems belong to the same class. Therefore, notion of **Finite-Time Stability (FTS)** (in conjunction with ISS property) appeared to be a powerful tool to handle analysis of two (or more) interconnected systems (of the same class or of different nature). Hence, we will focus on tools to be used when looking at connection between different dynamical systems involving **some classes of PDEs (e.g. hyperbolic/parabolic PDEs).**

Research subject, work plan:

Concerning PDEs, most of the results on control theory for stabilization and estimation are based on asymptotic or exponential guarantees (see e.g. [1,2,3]) but, up to now, few works in the literature deal with FTS. Among them, only very few particular PDE (namely, 1D hyperbolic systems) are concerned: see [4] for systems of conservation laws, and of balance laws [5] and for 1D Parabolic PDEs, one can point out [6] and [7].

In this PhD thesis, we will investigate general characterizations of FTS property to be used for control and estimation. On one hand, we will deal with finite-time stability characterization based on *Lyapunov-based techniques*. Indeed, a helpful framework using semi-groups (e.g. abstract formulations in Banach spaces) can be used to extend what it has been done for finite-dimensional systems (e.g. [9, 10, 11, 12, 13, 14, 15]) to the infinite-dimensional case. On the other hand, since *Homogeneity theory* is known to facilitate finite-time control/estimation, we will reformulate the above mentioned Lyapunov-based results to obtain a new finite-time characterization using homogeneity. As a matter of example, as soon as the Lyapunov function turns out to be homogeneous with a negative homogeneity degree, then the finite-time stability property straightforwardly follows.

Then, we will design finite-time controllers and observers. To that end, we will mainly follow the so-called backstepping approach for PDEs [9]. It is worth recalling that in the last decade, the backstepping method has emerged as a promising and in particular systematic approach for the design of boundary controllers for systems governed by PDEs [16]. Roughly, the idea of the backstepping method is to use an invertible Volterra integral transformation to convert a PDE system (usually unstable) into a stable PDEs (with some nice stability properties), which is usually called a target system. In addition, one of the most striking features of the backstepping approach is the possibility to obtain closed-form analytical solutions for the kernels and for the controllers. Having analytical expressions makes implementation simpler and more precise. Regarding the observers, collocating sensors in a suitable way (and based on available measures) at very point-wise locations in the domain at the boundaries will allow to reconstruct the state of system. The goal is to achieve a finite-time convergence of the observer to the estimated states.

References:

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Supervisors

Supervisor: Prof. Wilfrid Perruquetti

Co-supervisor: Dr. Nicolas Espitia

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Request Background

Candidates should have a strong background in mathematics and in control systems.

Skills in MATLAB/SIMULINK (mandatory) or Phyton will be appreciated.

Languages: English (mandatory), French (not mandatory).

Salary

Monthly gross salary: between 1800/2100 € (euros)

Monthly net salary: between 1400/1700 € (euros)

(including Social security coverage)

Application deadline

Interested candidates should send a detailed CV, a motivation letter and transcripts of grades to Prof. Wilfrid Perruquetti (with copy to Dr. Nicolas Espitia) by **the 10th of April, 2020**.

About the Laboratory

CRIStAL (Research center in Computer Science, Signal and Automatic Control of Lille) is a laboratory (UMR 9189) of the National Center for Scientific Research, University Lille 1 and Centrale Lille in partnership with University Lille 3, Inria and Institute Mines Telecom.

CRIStAL was founded on January 1st, 2015 and it is one of the partners of the institute of interdisciplinary researches IRCICA-USR CNRS 3380.

The laboratory is composed of about 430 members (228 permanent employees and more than 200 non-permanent employees) among whom 24 permanent employees of the CNRS and 31 of Inria.

Main CRIStAL Research activities involve topics related to major scientific and social issues such as Big Data, software, image and its uses, human-computer interaction, robotics, control and supervision of large systems, intelligent vehicle systems, bio-informatics and so on, with applications in retails, technologies for health, smart grids.