CCC2016 Workshop 1: Nonlinear Systems and Control

Part Ⅰ :U-model and the other emerging methodologies in nonlinear system identification and control

Speaker: Quanmin Zhu (University of the West of England, Bristol, UK)

Objective: The goal of this workshop is to provide an overview on some of recently emerging and less attended methodologies in analysis and design of nonlinear dynamic system modeling, identification and control (MIC); targeted participants include researchers and graduate students interested in MIC, stochastic data processing, and research method.

Abstract: In natural systems (such as those in natural world) and manmade systems (such as those in engineering applications), nonlinearity, one of the fundamental characteristics exhibited in simple and complex systems, exists almost everywhere. Linearity is just a piecewise or point wise approximation to nonlinearity. In convention, linear approximation techniques to nonlinearities have been widely used in model expression and control system design to make linear analysis design approaches applicable. However these will lose originality of nonlinear problems in various aspects and give less taste of academic challenge in research. Recent studies from the organisers have devoted to establishing platforms to make nonlinear problems resolved with linear approaches but without linear approximation to the original nonlinear problems.

The scope of this workshop focuses on some relative new methodologies, which besides introduction of the technical contents, may provide examples for finding new research topics and for further exploring/establishing new research areas. The other is the paper publication potential due to the topics less known and almost appeared on top journals yet, which need more collaborative work.

The first part of the workshop, <Dealing with nonlinearities in dynamic system modeling, identification and control --- linear approaches (but not linear approximation)>, is composed of two chapters, 1) Rational (total) nonlinear model identification and 2) U-model methodology for nonlinear control systems design.

In Chapter 1), Hypothesis: Least squares algorithms also can be used for model structure detection and parameter estimation for those complex models with nonlinear in the parameters.

In Chapter 2), Hypothesis: It is possible to use linear methodologies to directly provide design solutions for control of a large class of smooth nonlinear dynamic plant models, and therefore to simplify and generalized nonlinear control system design in principle of parsimony.

To prove the hypotheses, accordingly, this part of the lecture will be delivered with a systematic qualitative and quantitative procedure from definition of the problems, property analysis, solutions, to demonstrations. In addition some of the blue-sky issues for the future research are explained with the best knowledge of the presenters.

The second part of the workshop, <U-Model control design— State of the art>, will introduce the original idea on the U-mode control design, its recent developments and the future challenging issues. U-mode control presents a new architecture for nonlinear control design, which uses the conventional discrete time linear control approaches to solve the strong nonlinear control issues.

(A) The motivation of the U-mode control design and its potential applications.

(B) The philosophy of the U-mode control with a simple control design example.

(C) The changeling issues which make this control approach to be a long term fundamental research subject.

The last part of the workshop, <A novel adaptive algorithm and its application to estimation and control – Theory and practice> will present a recently developed novel adaptive algorithm for the parameter estimation and control of continuous systems, which can be used to solve the estimation, control and optimization in engineering and general science. This part will cover the following contents:

A) Brief introduction of conventional adaptive estimation and control methods, which shows the motivation to study new robust and fast adaptive algorithms beyond the gradient, least squares algorithms and available robust modifications;

B) Theoretical development of a new robust adaptation algorithm, which permits data forgetting and robustness properties, while achieving convergence to the true parameter. This algorithm is developed by deriving new leakage terms that contain the parameter estimation errors to drive the adaptive laws. This methodology leads to a new estimation and control framework, which also provides an intuitive and numerically feasible approach to online verify the PE condition.

C) Practical examples of this new adaptation algorithm in application to the real-time estimation of in-car parameters, the control of humanoid robotics and the synthesis of adaptive optimal controlwith approximate dynamic programming (ADP). We will finally show how this algorithm can aid to tackle these real-world engineering problems.

Quanmin Zhu is Professor in control systems at Department of Engineering Design and Mathematics, University of the West of England, Bristol, UK. He obtained his MSC in Harbin Institute of Technology, China in 1983 and PhD in Faculty of Engineering, University of Warwick, UK in 1989. His main research interest is in the area of nonlinear system modeling, identification, and control.

Currently Professor Zhu is editor/founder of International Journal of Modeling, Identification and Control (http://www.inderscience.com/ijmic), editor of International Journal of Computer Applications in Technology (http://www.inderscience.com/ijcat), and president/founder of International Conference on Modeling, Identification and Control (http://icmic.org.uk/).

Part Ⅱ:New Tools for Nonlinear Control of Dynamic Networks

Speaker: Tengfei Liu (Northeastern University, China)

Zhong-Ping Jiang (New York University, USA)

Abstract: Physical systems are inherently nonlinear and interconnected in nature. Significant progress has been made on nonlinear control systems in the past three decades. However, new system analysis and design tools that are capable of addressing more communication and networking issues are still highly desired to handle the emerging theoretical challenges underlying the new engineering problems. As an example, small quantization errors may cause the performance of a "well-designed" nonlinear control system to deteriorate.

The purpose of this half-day preconference workshop is to introduce a set of novel analysis and design tools to address the newly arising theoretical problems from the viewpoint of dynamic networks. The results are intended to help solve real-world nonlinear control problems, including quantized control, event-based control and distributed control aspects.

This tutorial is based on the authors' recent research results on nonlinear control of dynamic networks. In particular, it introduces refined nonlinear small-gain results for dynamic networks and their applications in solving the control problems of nonlinear uncertain systems subject to disturbance, quantization error, and other information exchange constraints.

Outline:

- Stability and Stabilization Problems of Dynamic Networks
- Input-to-State Stability
- The Nonlinear Small-Gain Theorem
- Small-Gain Designs
  - Quantized Nonlinear Control
  - Event-based Control
  - Distributed Nonlinear Control

Remarks: The workshop is suitable for graduate students and junior faculty who want to enter the field of modern nonlinear control or know more about recent developments in nonlinear small-gain theory. The prerequisite required of the audience is the basic working knowledge of nonlinear systems theory at the level of Khalil's awarding winning textbook ("Nonlinear Systems", 3rd edition, 2002).