Workshop on Control at Kyoto
"Recent Topics in Control"

December 21, 2015

Katsura Campus, Kyoto University

Organizers:

Yoshio Ebihara (Kyoto University, Japan)
Dimitri Peaucelle (LAAS-CNRS, Toulouse, France)

Program

9:00-	Registration Open
9:50-10:00	Opening Address

Morning Session

Chair: Yoshio Ebihara (Kyoto University, Japan)

10:00-10:40 Robust Observed-State Feedback Design for
Discrete-Time Systems Rational in the Uncertainties
Dimitri Peaucelle (LAAS-CNRS, Toulouse, France) in collaboration with
Yoshio Ebihara (Kyoto University, Japan) and
Yohei Hosoe (Kyoto University, Japan)

10:40-11:20 An Approach to Nonlinear Sampled-Data Control with Techniques of
Validated Computation and Positive Polynomials
Yasuaki Oishi (Nanzan University, Japan)

11:20-12:00 Equivalent Conditions for Synchronization of Identical Linear Systems
and Application to Quality-Fair Video Delivery
Luca Zaccarian (LAAS-CNRS, Toulouse, France)

Lunch

12:00-13:20 at Cafeteria

Afternoon Session I

Chair: Dimitri Peaucelle (LAAS-CNRS, Toulouse, France)

13:20-14:00 Parsimonious Model Identification via Atomic Norm Minimization
Constantino Lagoa (Pennsylvania State University, USA)

14:00-14:40 Dual LMI Approach to H_∞ Performance Limitations Analysis
Yoshio Ebihara (Kyoto University, Japan) in collaboration with
Hayato Waki (Kyushu University) and
Noboru Sebe (Kyushu Institute of Technology)

14:40-15:20 Linearized Fuel-Optimal Space Rendezvous:
Some Theoretical and Numerical Aspects
Denis Arzelier (LAAS-CNRS, Toulouse, France)

Tea Break

15:20-15:40

Afternoon Session II

Chair: Noboru Sebe (Kyushu Institute of Technology, Japan)

15:40-16:20	Measuring the Instability in Parametric Linear Systems Graziano Chesi (Hong Kong University, Hong Kong)
16:20-17:00	Design Problem of Gain-Scheduled Controllers using Bounded Inexact Scheduling Parameters and Its Application to Flight Controllers Masayuki Sato (JAXA, Japan)

Dinner Party

18:00-	Restaurant at City Center

Dimitri Peaucelle
LAAS-CNRS, Toulouse, France

Title: Robust Observed-State Feedback Design for Discrete-Time Systems Rational in the Uncertainties

Abstract: Observer design is classically considered as a dual problem to state feedback. But very few results address this issue in the context of uncertain system, at least in comparison of robust state-feedback design. This fact has motivated us for studying robust design of both state-feedback gains and Luemberger-like observers and we in particular show that in case of uncertain systems these two designs are inevitably coupled. The separation principle does not hold in general. The proposed results use recent tools in robust control such as $\mathcal{S}$-variable approach and descriptor modeling of uncertain systems. It also gives the opportunity to introduce a promising multi-affine descriptor modeling for systems rational in the uncertainties.

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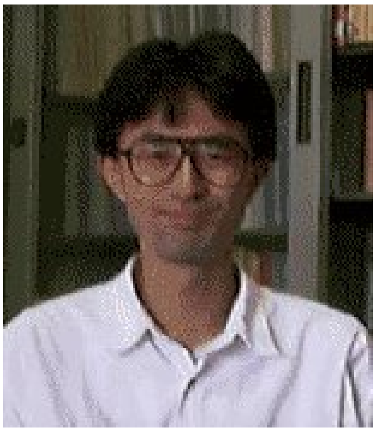

Yasuaki Oishi
Nanzan University,
Japan

Title: An Approach to Nonlinear Sampled-Data Control with Techniques of Validated Computation and Positive Polynomials

Abstract: A typical approach to sampled-data control is to discretize a given plant and then design a controller in discrete time. In the case of a nonlinear plant, however, this approach becomes problematic because exact discretization is often impossible and approximate discretization often lacks evaluation of an approximation error. With techniques of validated computation and positive polynomials, we can explicitly evaluate this approximation error and use it for sampled-data control of a nonlinear plant. This topic is basically the same as my presentation at the CDC. However, more attention is paid on an advanced part such as how the intersample behavior is taken into account in controller design.

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Luca Zaccarian
LAAS-CNRS, Toulouse, France

Title: Equivalent Conditions for Synchronization of Identical Linear Systems and Application to Quality-Fair Video Delivery

Abstract: We consider the problem of consensus of multi-agent systems, consisting of a set of identical continuous or discrete-time systems with generic dynamics, connected through a network with fixed topology. The information exchanged over the communication network is the output of each system. First, necessary and sufficient conditions are given for the uniform global exponential stability of the state consensus set. Subsequently, we apply these necessary and sufficient conditions for the sub-optimal tuning of a set of PI gains in a quality-fair delivery of media contents application. In particular, we present a few approaches for the selection of the PI gains. In the first one the they are heuristically tuned in order to maximize the convergence speed to consensus. The second strategy proposes a systematic iterative design technique based on Linear Matrix Inequalities (LMIs). We show simulation results illustrating the effectiveness of the approach to obtain substantial improvements as compared to the existing approaches.

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Yoshio Ebihara
Kyoto University,
Japan

Title: Dual LMI Approach to H_∞ Performance Limitations Analysis

Abstract: In this talk, we present a dual-LMI-based approach to the H_∞ performance limitations analysis of SISO systems. The H_∞ performance limitations for the sensitivity and the complementary sensitivity functions are well investigated, and exact closed-form performance bounds are already known for the cases where the plant has the sole unstable zero of degree one or the sole unstable pole of degree one. The first goal of this talk is to show that such exact bounds can be reproduced by a dual LMI approach. To this end, we study a Lagrange dual of the standard SDP that is usually used to design H_∞ optimal controllers by numerical computation. By characterizing the structure of dual feasible solutions in terms of unstable zeros and unstable poles, we clarify that we can construct an optimal solution for the dual SDP analytically. It follows that we obtain exact H_∞ performance bounds that are consistent with the known results. On the other hand, such exact bounds are hardly available for the cases where the plant has multiple (i.e., duplicated) unstable zeros and poles. To obtain a lower bound of the best achievable H_∞ performance for such involved cases, we derive a parametrization of dual feasible solutions and construct a dual suboptimal solution analytically. We thus readily obtain a lower bound of the best achievable H_∞ performance. Extensive numerical examples show that the lower bound is very close to the exact H_∞ performance bound.

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Constantino Lagoa
Pennsylvania State University, USA

Title: Parsimonious Model Identification via Atomic Norm Minimization

Abstract: During the past few years a considerably research effort has been devoted to the problem of identifying parsimonious models from experimental data. Since this problem is generically non-convex, these approaches typically rely on relaxations such as Group Lasso or nuclear norm minimization. However, while these approaches usually work well in practice, there is no guarantee that using these surrogates will lead to the simplest model explaining the experimental data. In addition, incorporating stability constraints into the formalism entails a substantial increase in the computational complexity. Alternatively stability and model order constraints can be handled directly using a moments based approach. However, presently this approach is limited to relatively small sized problems, due to its computational complexity. Motivated by these difficulties, recently a new approach has been proposed based on the idea of representing the response of an LTI system as a linear combination of suitably chosen objects (atoms) and the observation that minimizing the atomic norm leads to sparse representations. In this talk, we cover the fundamentals of this new approach and show that it leads to a very efficient algorithm, that avoids the need for using regularization steps and automatically incorporates stability constraints. In addition, this approach can be extended to accommodate non-uniform sampling and (unknown) initial conditions.

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Graziano Chesi
Hong Kong University,
Hong Kong

Title: Measuring the Instability in Parametric Linear Systems

Abstract: Measuring the instability is a key problem in control systems. This talk considers linear systems depending polynomially on parameters constrained in a semialgebraic set, and addresses the computation of the largest value of a key measure of the instability defined as the sum (continuous-time case) or the product (discrete-time case) of the unstable eigenvalues. It is shown that upper bounds of the sought measure can be established through linear matrix inequalities (LMI) by exploiting polynomially dependent quadratic Lyapunov functions and sums-of-squares (SOS) matrix polynomials. Moreover, several conditions for establishing the tightness of these upper bounds are proposed.

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Denis Arzelier
LAAS-CNRS, Toulouse, France

Title: Linearized Fuel-Optimal Space Rendezvous:
Some Theoretical and Numerical Aspects

Abstract: The optimal fuel impulsive time-fixed rendezvous problem is shortly reviewed in the context of the more general problem of impulsive optimal control. In a linear setting, it may be reformulated as a non convex polynomial optimization problem for a pre-specified fixed number of velocity increments. Some theoretical results are first recalled and different algorithms are presented. In particular, when addressing the problem of a free number of maneuvers, one has to resort to a mixed iterative algorithm involving the solution of a convex optimization problem at each step. Examples of realistic rendezvous missions will illustrate this talk.

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Masayuki Sato
JAXA,
Japan

Title: Design Problem of Gain-Scheduled Controllers using Bounded Inexact Scheduling Parameters and Its Application to Flight Controllers

Abstract: This presentation addresses the design problem of Gain-Scheduled (GS) controllers using inexact scheduling parameters. In practical systems, it does not always hold that exact scheduling parameters are provided to GS controllers. Thus, we first show several numerical examples which illustrate that the uncertainties in the provided scheduling parameters deteriorate the control performance obtained in the design phase. Then, we show a design method of GS controllers which are robust against the uncertainties in the provided scheduling parameters. Finally, an application example of our proposed method to flight controller design is shown with flight test results.

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