



IEEE – CS/R&A Joint Societies Chapter, Queensland
ITEE Branch Committee – Queensland, Engineers Australia, and
Electrical Branch Committee – Queensland, Engineers Australia
present

Professional Development Workshop
**NON-LINEAR CONTROL METHODS AND
TOOLS: WHEN AND HOW TO USE
THEM?**

Date: Monday 1 November 2004
Time: 12:30 for 1:00pm to 6.00pm (Light refreshments will be provided from 12:30)
Venue: Hawken Auditorium, Engineering House
447 Upper Edward Street, Brisbane
Cost: \$150.00 – EA & IEEE members; \$300.00 – Non-members
RSVP: RSVP by 27 October. See back of flyer for details.

PROGRAM

The purpose of the Workshop is to present in a tutorial fashion a selection of recently developed user-friendly tools for nonlinear control design, accessible to practicing engineers. The tools for both finite and infinite dimensional (distributed) systems will be illustrated by typical applications.

1:00pm – 2:30pm

NONLINEAR FEEDBACK DESIGN: AN INTRODUCTION THROUGH APPLICATIONS

Dr Petar V Kokotovic

Professor, Center for Control Engineering & Computation
Department of Electrical & Computer Engineering
University of California, Santa Barbara, USA

Most of the new design tools emerged by 'activating' some classical descriptive concepts. Thus, a Control Lyapunov Function (CLF) is used for systematic Lyapunov-based stabilization and tracking designs with robustness margins for bounded uncertainties. A detailed example of a stall stabilization design for an axial compressor will illustrate the design steps and discuss verification by experiments.

Passivity is another classical concept which has been 'activated' into several passivation designs. They exploit system structure and input/output choices (true or virtual) to achieve desired properties with minimal alteration of system structure. This approach is illustrated by a turbo-charged diesel engine controller design.

New tools can be combined into recursive procedures. One of them is backstepping, which is now one of the most widely used nonlinear designs. Several features of backstepping will be illustrated by examples.



2:30pm – 2:45pm Refreshment

2:45pm – 4:15pm

DISTRIBUTED PARAMETER SYSTEM CONTROL AND APPLICATIONS TO TURBULENT FLOWS

Dr Miroslav Krstic

Professor, Department of Mechanical and Aerospace Engineering,
University of California, San Diego, USA

Distributed parameter dynamics are essential in applications involving fluids, flexible structures, etc. Until recently, control tools for such systems relied on advanced mathematical techniques for partial differential equations, semi-group theory, Sobolev spaces, etc. A new set of tools, based on infinite dimensional extensions of backstepping, is accessible to engineers whose background does not go beyond calculus. With these tools boundary controllers for distributed parameter systems can be designed without the need to solve operator Riccati equations. In several cases of practical interest these tools provide explicit formulae for control laws.

The new design tools have recently been used for control of fluid flows, either for turbulence suppression or for enhancement of fluid mixing in problems like combustion. Such designs are implementable with new generation of micro-electromechanical (MEMS) actuators and sensors.

Several designs for fluid flows in channels, pipes, jet flows, and flows around bluff bodies, to be presented are motivated by benchmark geometries of aircraft wings and forebodies, and flows in combustion chambers and scramjet engines. The designs employ passivation/CLF ideas adapted to the Navier-Stokes equations.

Extremum seeking, a classical real-time optimization method, has recently become a systematic procedure with stability guarantees, accounting for the presence of nonlinearities and transients. Its simplicity has made it attractive for diverse applications that include automotive and aero engines, chemical and biochemical processes, formation flight, particle accelerators, and even exercise machines. Some of these will be reviewed in the talk.

4:15pm – 4:30pm Refreshment

4:30pm – 6:00pm

SERVO DESIGN FOR THE AUSTRALIA TELESCOPE

Dr Iven Mareels

Professor, Department of Electrical and Electronic Engineering
University of Melbourne, Australia

We discuss the control design issues surrounding large antennae, using as a case study the Australia Telescope. The design philosophy is transferrable to many electro-mechanical systems. We discuss the entire design, starting from the control objective specifications, include the physical modeling, the design of the actual control (actuator, sensor) hardware structures to the final design of the control algorithms themselves. The control approach combines elements of classical frequency domain based control with modern adaptive designs. The control ideas are closely related with the backstepping formalism introduced recently by Prof Kokotovic and co-workers to address control in nonlinear systems.



The talk summarises a decade of experience with large antennae used for radio-astronomy, communications and satellite tracking by a group of control engineers lead by Prof Rob Evans.

SPEAKERS

Professor Petar V. Kokotovic

University of California, Santa Barbara, USA

Petar V. Kokotovic received his Dipl. Ing. and M.S. degrees in Electrical Engineering from the University of Belgrade, Yugoslavia, and his Ph.D. degree from the Institute of Automation and Remote Control, Moscow, USSR, in 1958, 1962, 1965 respectively. From 1958 until 1966 he was with the Pupin Institute in Belgrade. In 1966 he joined the University of Illinois, Urbana, where until 1991 he held the Grainger Endowed Chair in Electrical Engineering. In 1991, Professor Kokotovic moved to the University of California, Santa Barbara, where he co-founded the Center for Control Engineering and Computation and served as its director, 1991-2003.

In the early 1960's Kokotovic developed the "sensitivity points method", still used in industry. In the 1970's, he pioneered singular perturbation techniques, which found widespread applications, including coherency-based aggregation of power systems. In the 1980's his methods made adaptive controllers more robust. In the 1990's, he initiated the popular nonlinear recursive design-backstepping. As a long-term industrial consultant, Kokotovic contributed to computer controls at Ford, and to power system stability at General Electric.

With his 30 Ph.D. students and 20 postdoctoral researchers, Kokotovic co-authored numerous papers and ten books. He is a fellow of the IEEE and a member of the U.S. National Academy of Engineering. He received the 1990 IFAC Quazza Medal, the 1995 IEEE Control Systems Field Award, the 1987 D.C. Drucker Eminent Faculty Award, the 1983 and 1993 Outstanding IEEE Transactions Paper Awards, and delivered the 1991 IEEE Control Systems Society Bode Prize Lecture. His most recent recognitions are the 2002 IEEE James H. Mulligan Jr. Education Medal and the 2002 ACC Richard E. Bellman Control Heritage Award.

Professor Miroslav Krstic

University of California, San Diego, USA

Miroslav Krstic is Professor and Vice Chair in the Department of Mechanical and Aerospace Engineering at University of California, San Diego. Prior to moving to UCSD, he was Assistant Professor in the Department of Mechanical Engineering and the Institute of Systems Research at University of Maryland (1995–97). He got his PhD in Electrical Engineering from University of California at Santa Barbara, under Petar Kokotovic as his advisor, and received the UCSB Best Dissertation Award. Krstic is an IEEE Fellow and has received the National Science Foundation Career Award, the Office of Naval Research Young Investigator Award, the Presidential Early Career Award for Scientists and Engineers (PECASE), the George S. Axelby Outstanding Paper Award of IEEE Transactions on Automatic Control, and the O. Hugo Schuck Award for the best paper at American Control Conference. Krstic is a co-author of the books *Nonlinear and Adaptive Control Design* (Wiley, 1995), *Stabilization of Nonlinear Uncertain Systems* (Springer-Verlag, 1998), *Flow Control by Feedback* (Springer-Verlag, 2002), and *Real Time Optimization by Extremum Seeking Control* (Wiley, 2003). He is a co-author of two patents on control of aero-engine compressors and combustors. He has served as Associate Editor for the IEEE Transactions on Automatic Control, International Journal of Adaptive Control and Signal Processing, Systems and Control Letters, and Journal for Dynamics of Continuous, Discrete, and Impulsive Systems. Krstic is a Vice President for Technical Activities and a member of the Board of Governors of the IEEE Control Systems Society.

His research interests include nonlinear, adaptive, robust, and stochastic control theory for finite dimensional and distributed parameter systems, and applications to fluid flows and fusion.

Professor Iven Mareels

The University of Melbourne, Australia

Iven Mareels was born in Aalst Belgium 11 August 1959. He obtained the Bachelor of Electromechanical Engineering from Gent University, Belgium in 1982 and the PhD in Systems Engineering from the Australian National University, Canberra, Australia in 1987. He is presently Professor at the Department of Electrical and Electronic Engineering, the University of Melbourne, where he holds the Chair of Electrical and Electronic



Engineering, a position he took up in 1996. He is a co-editor in chief, together with Prof. A. Antoulas for the international Journal Systems & Control Letters. He is Fellow of the Academy of Technological Sciences and Engineering, Australia, a Fellow of the Institute of Electrical and Electronics Engineers (USA), a member of the Society for Industrial and Applied Mathematics, a Fellow of the Institute of Engineers Australia, Vice-Chair of the Asian Control Professors Association, Chairman of the Education Committee of the latter, and a member of the Steering Committee for the Asian Control Conference. He is a member of the Board of Governors of the Control Systems Society IEEE. He is registered with the Institute of Engineers Australia as a professional engineer and he is Deputy Chair of the National Committee on Automation, Control and Instrumentation.

Iven Mareels has taught a broad range of subjects in both mechanical and electrical engineering curricula. His research interests are in adaptive and learning systems, nonlinear control and modelling. He has co-authored 3 research monographs, 100 journal papers and 150 conference publications and received several awards for his publications.

Yes, I will be attending the Non-Linear Control Methods and Tools Seminar on 1 November 2004

To register:

- Registrations can be made online at www.qld.engineersaustralia.org.au
- Fax your registration to (07) 3832 2101
- Email a completed form to Daniel Seguin at dsequin@engineersaustralia.org.au

NB Registrations close 27 November 2004.

Name (s) _____
Company _____
Address _____
Telephone _____ E-mail _____

Members \$150.00 (Inc GST)
Non-members \$300.00 (Inc GST)

Payment by cheque: Please make cheques payable to the Engineers Australia, QLD Division

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Registrations may be faxed ONLY if credit card payment is included.

Once completed this form is a valid tax invoice. ABN 54 586 415 692