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## Foreword

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On behalf of the IEEE Control Systems Society, the Organising Committees and the International Programme Committees we should like to welcome you to the Joint 2002 Conference on Control Applications and the Computer Aided Control Systems Design Symposium in Glasgow, Scotland, U.K.

Many of you may well remember that Glasgow was the location for the Conference on Control Applications in 1994. So we are pleased to be able to extend the warmest of welcomes once more. In the intervening years the city has changed and the historic Victorian past of Glasgow has been much more widely recognised. You will find the city has been extensively pedestrianised and visitors now tell us that we have a beautiful city as well as an extremely friendly one. The conference is located in the new Scottish Exhibition and Conference Centre by the side of the River Clyde. All the session rooms are equipped with state of the art data projection facilities and so we expect to see a high level of presentation through-out the conference.

### The Conference on Control Applications, 2002

From the very beginning the IEEE's CCA Conference has been an international event that is held outside the United States at least every three years. The focus of these meetings is on the use of *Advanced Control in Industrial Applications* and the Glasgow meeting has an excellent range of application sessions across industrial sectors.

The four Plenary presentations for the CCA Conference are:

- Professor Kumpati Narendra, Yale University, who will be considering the question of when to tune controllers.
- Dr Jeff Cook of Ford Motor Company, in Dearborn, U.S.A will consider problems in automotive powertrain control applications and the opportunities these provide.
- Professor Sanjoy Mitter of MIT will discuss the very topical subject of the convergence between communications, computing and control sciences.
- Professor Roger Benson, F.Eng., of ABB, who will present the final CCA Plenary on the use of automation in process control.

The CCA Plenary lectures therefore cover a range from new technologies and concepts to real applications experience with advanced control. There will be five parallel sessions of the CCA Conference and two for the CACSD and delegates will be able to attend either, since they will be held in the same area of the Exhibition Centre. The sessions cover technical areas that have real applications potential, in addition to industry specific subjects that demonstrate the importance and value of the control systems discipline.

Two Special Sessions have been organised on the theme of Control, and Industrial Problems. The first is sponsored by the local IEE Section who have arranged for a group of industrialists and engineers from industries to give short presentation on current industrial problems in a wide range of industrial sectors. The second Special Session has been organised to allow delegates to learn something of international and national funding mechanisms that are in place to assure the future developments of the control discipline and its application.



## **The Computer Aided Control System Design Symposium, 2002**

The CACSD Symposium 2002 will run in parallel and has three Plenary Speakers:

- Ing. Adriano Cavallanti Da Silva of Darmstadt University who will talk on advanced graphic simulation methods.
- Dr Barry Lennox of the University of Manchester who will speak on Principal Component Analysis methods.
- Dr Paul Austin of INVENSYS who will speak on the use of predictive control in the paper industry.

The Symposium comprises two tracks over two days and covers topics which include research work on multi-objective control system design and non-linear control system design methods.

### **The Tutorial Workshops**

Four really excellent Tutorial Workshops have been organised covering both CCA and CACSD topics. Controller performance assessment, nonlinear control design, modelling and simulation using the internet and petri nets in control are all current state-of-the-art topics in industrial control and CACSD. We kindly thank the Workshop Chairs Mike Masten and Gerald Hearn and the Workshop presenters for all their effort in arranging these events.

### **Social and Hospitality Programme**

In parallel with the technical events there is a strong social programme that follows the usual tradition including both a welcoming reception and a farewell reception. In addition, there will be a civic reception in Glasgow City Chambers, which is a very impressive building in the middle of Glasgow that represents the seat of local Government. There will also be a conference banquet at the Moat House Hotel which is next to the Exhibition Centre. The banquet will have a strong Scottish theme in the menu and a welcoming piper. Unfortunately Scotland can not provide its own wine but a wee dram when you arrive at the banquet should more than compensate for this. The venue should provide an excellent opportunity for networking and for exhibitors. In addition to the excellent facilities in the Exhibition Centre next to the River Clyde, delegates will have the opportunity to walk along the Clyde or across to the new Science Centre that includes a range of interesting exhibits.

### **Thanks and Acknowledgements**

Firstly we should like to thank staff at the SECC (Robin Miller and Jacqui Thomson) for their care and help in putting together the facilities we needed to host the conference at the SECC. The Lord Provost of Glasgow is also thanked for hosting a welcoming Civic Reception for conference delegates. We should also like to thank Bob Hamm and Lisa Pernacciaro of Omnipress who helped us create the Proceedings and CD ROMS's with efficiency and courtesy.

For compiling the Technical Programme, overseeing the Review Process and creating the timetable we thank Professors Derek Atherton (CCA) and Neil Munro (CACSD) along with the Invited Session Chairs Professor Harris McClamroch and Dr Dawei Gu and the respective International Programme Committees for such an excellent programme of papers and Plenary speakers.

The Organising Committee deserve thanks, too. An event like this cannot come together without teamwork and Jacqueline Wilkie, Paul Kalata, Ron Leigh and Mike Johnson worked tirelessly to bring the event together.



Final grateful thanks go to the CCA/CACSD Secretariat Drew Smith, Sheena Dinwoodie and Ann Hall for their amazing effort and unfailing good humour during the last twelve months of organising the 2002 CCA/CACSD event.

We extend a warm welcome to all our delegates and hope that you enjoy your visit, and achieve all your personal conference objectives.

Michael Grimble  
General Chair CCA

John Gray  
Chair CACSD

P.S.: We would like to acknowledge the following individuals who accepted as Chairs and Co-Chairs after the Author Index was published. Thank you for lending your support and time for the following sessions:

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ThE7 - Chair: Michael Sebek, Czech Academy of Sciences

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## CONFERENCE HIGHLIGHTS

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### Technical Program Overview

With the assistance of an excellent Technical Program Committee, we have been able to put together a very exciting technical program for the Joint 2002 Conference on Control Applications and the Symposium on Computer Aided Control Systems Design. In order to retain the character of CCA and CACSD, we have maintained separate tracks for the two as can be found on the Conference Overview pages. The technical program is spread over three days and each day we have morning, early afternoon, and late afternoon sessions. There are four CCA Plenary Lectures. A summary of Technical Program can be seen in the Program at a Glance – note that the titles of sessions have been abbreviated to accommodate the program on a single page.

### CCA Plenary Lectures

CCA Plenary 1 Kumpati Narendra

Date: Wednesday 18th September, 2002  
Lomond Auditorium, 08.45 a.m.

Address: Centre for System Science,  
Department of Engineering and Applied Science,  
PO Box 208267,  
New Haven,  
CT 06520-8267,  
Yale University, USA

**Title:** To Tune, To Switch, or To Switch and Tune? Adapting to Constantly Changing Environments

### Abstract:

The term "Adaptive Control" was defined in the late 1950s, and during the following four decades has come to refer to systems that monitor their own performance, and adjust their characteristics to cope with changing environments. For the most part, research in the field has dealt with plants with constant but unknown parameters, and adaptation is carried out by the incremental adjustment (tuning) of controller parameters based on the measurements of the input and the output of the plant. The methods, originally developed for deterministic linear systems, have been extended to linear stochastic systems, as well as nonlinear systems in which the parameters occur linearly. Demonstrating that the adaptive system is stable, that all the signals remain bounded, and that performance of the system is improved by adaptation have been the main topics discussed in the literature.

Intuitively, it seems reasonable to expect such adaptation to perform satisfactorily even in the presence of small plant parameter perturbations as well as slow but large variations, and such problems have also been discussed in the literature.

With systems becoming more complex, and adaptive control finding application in wider domains, controllers are increasingly called upon to cope with sudden and large variations in plant parameters, as well as changes that occur constantly. New adaptive paradigms are needed to deal with such situations. In the past decade, methods have been developed based on multiple models of the plant where adaptation is carried out by discontinuous changes in controller parameters (switching).

The lecture will discuss both tuning and switching in adaptive control, and how the two can be combined to address a much wider class of problems in adaptation. While the new methodology has given rise to many new theoretical questions, the emphasis of the lecture will be on the application to practical problems, including aircraft control, process control, and the control of mechanical systems.

#### **Biographical Sketch:**

Professor K.S. Narendra received his Bachelor of Engineering degree with honors in Electrical Engineering from the University of Madras in 1954, and the M.S. and Ph.D. degrees from Harvard University in 1955 and 1959 respectively. He received an honorary M.A. degree from Yale University in 1968 and an honorary Doctor of Science degree from his alma mater (now Anna University in Madras) in 1995. Currently, he is Professor of Electrical Engineering and Director of the Center for Systems Science at Yale University.

Professor Narendra's research since 1961 has addressed four different areas: Stability Theory (1961-1972), Learning Automata (1968-1987), Adaptive Control (1970-present) and Artificial Neural Networks (1988-present). Concurrent with research he has directed forty doctoral students at Harvard and Yale Universities, and collaborated with over fifty postdoctoral and visiting fellows.

Professor Narendra is the author of four books on stability, learning automata, adaptive systems and neural networks (in preparation), and the editor of four others. He is the recipient of the Franklin V. Taylor Award (1972) of the IEEE Systems, Man, and Cybernetics Society, the George S. Axelby best paper award (1988) of the Control Systems Society, and the Outstanding Paper Award (1991) of the Neural Network Council. He is a Life Fellow of the IEEE, a Fellow of IEE (U.K.), a Fellow of the American Association of the Advancement of Science, and a member of the Connecticut Academy of Science and Engineering (1995). He was awarded the American Automatic Control Council Education Award in 1990, the Leadership Award of the Neural Network Society (1994) and the Bode Prize in 1995.

Professor Narendra has served on numerous national and international committees as well as the advisory boards of various institutes and universities around the world. His current interests are in the control of complex systems in the presence of large time-varying uncertainties.

**CCA Plenary 2** Jeff Cook

**Date:** Wednesday 18<sup>th</sup> September 2002

Lomond Auditorium, 01.00 p.m.

**Address:** Ford Motor Company  
2101 Village Road,  
PO Box 2053,  
MD 2036/SRL  
Dearborn, MI 48121- 2053

**Title:** Opportunities in Automotive Powertrain Control Applications

#### **Abstract:**

Automotive emissions regulations and the requirement for improved fuel economy have driven innovation in powertrain design and control for more than three decades. In Europe, "Stage I" emission standards were introduced in 1992; in the United States, the very first requirements on automotive pollution control date to the mid-1960's. Throughout the world, much has been accomplished in this important area: almost everywhere, passenger vehicles are immensely cleaner and more fuel-efficient than they were only a relatively few years ago. The job, however, is far from done. In Europe, a 60% reduction in tailpipe emissions of oxides of nitrogen (NOx) is required in the next decade to transition from the current "Stage III" to "Stage V" emission levels (and diesels will be as clean as gasoline vehicles). In the United States, a ten-times reduction in NOx is necessary over the

x



same time period to achieve California's most stringent requirements. As for fuel economy, the European Automobile Manufacturers Association has committed to a reduction in carbon dioxide emissions (essentially, fuel consumption) for new passenger cars by over 25% to an average of 140 g/km by 2008. Corporate Average Fuel Economy (CAFE) regulations impose a minimum fleet average miles per gallon requirement in the U.S. Reductions in emissions and fuel consumption are societal obligations (regulated or not), but they cannot be accomplished with a disregard for performance: customers want vehicles that are fun to drive, responsive and achieve good fuel economy; they expect environmental stewardship.

These generally competing requirements of performance, fuel economy and emissions have fostered the development of advanced technology powertrains that are typically complex and control intensive: they incorporate new sensors and actuators, effect new methods of operation and are crucially dependent on the embedded control system to deliver the benefits of innovative powertrain hardware.

Although the control design problems for these advanced technology systems are in themselves difficult ones, achieving the required system performance is not the only challenge. The control systems for these complex powertrains must be developed at minimal cost and deployed in record time to meet the expectations of a competitive market. Today, the cost structure of the automotive industry imposes constraints on engineering resources, while rapid time-to-market pressures put the powertrain controller on the critical path of a vehicle's development schedule. Consequently, a systematic, model-based control development process that relies on modern Computer Aided Control Systems Design (CACSD) tools and methods is essential.

This plenary talk will describe a few of these "control-critical" advanced technology powertrain systems, some control solutions and some remaining opportunities. In addition, a systems engineering process that supports the development of advanced control systems in a production automotive environment will be presented.

#### Biographical Sketch:



Jeffrey A. Cook is a Staff Technical Specialist at the Ford Motor Company, Scientific Research Laboratory. His research addresses modeling and control of advanced technology automotive engines for improved fuel economy and emissions, and improvements in systems engineering processes for the design of automotive powertrain controls. He holds more than 20 patents on engine systems technology, and is an author of over 40 technical publications on automotive powertrain modeling and model-based control design. He is a Fellow of the IEEE. He received the BS degree in Mechanical Engineering from the Ohio State University in 1973, and an MS degree in Electronic and Computer Control Systems from Wayne State University in 1985.

CCA Plenary 3 Sanjoy Mitter

Date: Friday 20<sup>th</sup> September 2002  
Lomond Auditorium, 08.45 a.m.

Address: Massachusetts Institute of Technology  
77, Massachusetts Avenue  
Lab. For Information & Decision Systems  
Cambridge, MA 02139  
USA

**Title: System Science: The Convergence of Communication, Computation and Control**

**Abstract:**

This lecture is concerned with the study of large networks having a combination of sensing, control, communication and capabilities; ranging from rapidly deployable sensors to instrumented infrastructure. I argue that to study these problems a new synthesis of communication, control and computation is needed.

In this context, the boundary between sensors, actuators and control systems is blurred and each node of the network may reconfigure itself to act as a sensor, or actuator, or even as part of the environment (for instance posing as landmark for navigation of other nodes). The loop could include human operators at the highest level of abstraction, and the network itself represents a large, hybrid, hierarchical, composition, event-driven control system.

**Biographical Sketch:**



Sanjoy K. Mitter received his Ph.D. degree from the Imperial College of Science and Technology in 1965. He taught at Case Western Reserve University from 1965 to 1969. He joined MIT in 1969 where he has been a Professor of Electrical Engineering since 1973. He was the Director of the MIT Laboratory for Information and Decision Systems from 1981 to 1999. He has also been a Professor of Mathematics at the Scuola Normale, Pisa, Italy from 1986 to 1996. He has held visiting positions at Imperial College, London; University of Groningen, Holland; INRIA, France; Tata Institute of Fundamental Research, India and ETH, Zürich, Switzerland. He was the McKay Professor at the University of California, Berkeley in March 2000 and has held visiting positions in several American universities. He is a Fellow of the IEEE and a Member of the National Academy of Engineering. He is the winner of the 2000 IEEE Control Systems Award. His current research interests are Communication and Control in a Networked Environment, the relationship of Statistical and Quantum Physics to Information Theory and Control and Autonomy and Adaptiveness for Integrative Organization.

CCA Plenary 4 Roger Benson

Date: Friday 20<sup>th</sup> September, 2002  
Lomond Auditorium, 01.00 p.m.

Address: ABB Automation (UK) Ltd,  
Gunnels Wood Road,  
Stevenage,  
Herts.,  
SG1 2EL, U.K.

Title: Smart Control For Tomorrows Processes

Author – Professor R S Benson FREng – Director Technology – ABB UK

**Abstract:**

Reviewing the history of control in the processes industries it is clear that four key technologies have significantly influenced the performance.

- Process Control that has evolved from single loop pneumatic control through to multivariable dynamic matrix control applied to whole plants and potentially sites.
- Communication / interface technology where the evolution from pneumatic instruments through electronics to field bus and the current Industrial<sup>IT</sup> standard has been dramatic.
- The ability to model, initially in the steady state but now dynamically, the basic manufacturing processes.
- The improvements in the understanding of process engineering, process design and integration of the supply chain.

The paper will review the history in all four areas and suggest that as we enter the twentieth century, all four are approaching a point of integration.

There are two major drivers for change and potential restructuring of the industry.

- The poor financial and perceived performance of industry.
- The competitive pressures of the supply chain.

As a supplier to the process industries ABB recognises these strengths and is responding accordingly. The trend in the processes is towards a spectrum of manufacturing processes from the ever-larger continuous plants at the source of feedstock through to the distributed, intensified and small plants that work on a made to order basis at the point of use. In both cases these are “smart plants” where the control, and the knowledge, must be used to match the process output and quality to an ever more variable demand. This demands certain characteristics of the “smart controllers”. In addition the capabilities of the core technologies are allowing ever-larger processes to be controlled. The total supply chain from raw material through to the final customer is effectively a set of dynamic processes. The scope of smart control is now extending to the control of such processes with phrases such as profitability to promise gaining acceptance.

The paper will review how ABB is tackling this whole complex scenario through the development and exploitation of its Industrial<sup>IT</sup> platform.



## Biographical Sketch:



### Professor Roger Benson FREng

Roger Benson is Technology Director of ABB Limited and the Manager of the Refinery and Petrochemical Programme.

Prior to joining ABB he spent 30 years with ICI where he was Chief Engineer of Engineering Technology. Positions prior to that included creating the Manufacturing Technology capability; head of the Control / Electrical Function; starting New Businesses and a Works Maintenance Manager and a Control Engineer. Since 1994 he has been a judge for the UK Best Factory Award. From 1997 to 1999 he was a member of Manufacturing Foresight Panel. Since 1998 he has been chairman of the CPACT Foresight Initiative. In 2000 he was appointed to the EPSRC User Panel. In 1995 he completed a two year period with the Innovation Unit of the DTI, which included joint authoring "Competitiveness – how the best UK companies are Winning" and "Manufacturing Winners". While with the DTI he was the Process Sector Programme Manager for the EPSRC Innovative Manufacturing Initiative. In 1999 he was appointed a Fellow of the Royal Academy of Engineering. He is a Visiting Professor to the Centre of Process Systems Engineering at Imperial College, the Department of Chemical Engineering at the University of Newcastle and the University of Teesside. He is the author of the IChemE book on "Benchmarking Process Manufacturing", over 30 published papers, and has given much presentation on Innovation, Process Control, Benchmarking, World-class manufacturing and the future of the Process Industries.

In 1997 he presented the UKACC lecture and in 1998 the Plenary address at the IChemE Research Conference. In 1984 he was a finalist for the Prince of Wales Award for Innovation.

A native of Haslingden in Lancashire, he was educated at Swansea University and UMIST.

He and his wife Kathlyn live near Northallerton, North Yorkshire.

## TUTORIAL WORKSHOPS

There are four Tutorial Workshops to be held at the CCA/CACSD event. They will be held on Tuesday 17th September, 2002. The venue for the Workshops is the James Weir Building at the University of Strathclyde.

[http://www.strath.ac.uk/maps/james\\_weir.htm](http://www.strath.ac.uk/maps/james_weir.htm)

The lecture theatres being used are on Level 4 of this building.

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### WORKSHOP 1

#### Tutorial Workshop 1 Controller Performing Monitoring

Organisers Nina Thornhill and Mike Grimble  
Room M413, Level 4 James Weir Building,  
University Of Strathclyde

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### WORKSHOP 2

#### Tutorial Workshop 2 Design, Validation, And Implementation Of Logic Control Systems For Industrial Automation Using Petri Nets

Organisers Dawn Tilbury And Luca Ferrarini  
Room M422A, Level 4 James Weir Building,  
University Of Strathclyde

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### WORKSHOP 3

#### Tutorial Workshop 3 Web-Based Course On Modelling Of Multidisciplinary Systems With Simulation Across The Internet

Organiser Herman Mann  
Room M412, Level 4 James Weir Building,  
University Of Strathclyde

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### WORKSHOP 4

#### Tutorial Workshop 4 Nonlinear Dynamic Models For Computer Control

Organiser Ronald K. Pearson  
Room M415, Level 4 James Weir Building,  
University Of Strathclyde

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## SPECIAL SESSIONS

**DATE: Thursday 19<sup>th</sup> September, 2002**

Special Session ThM7: Control Problems and Solutions in Industry  
Chair: D. R. Booth Co-Chair: R. Dahtz  
Location: Carron 2  
Time: ThM7 10.00 to 12.00 noon

What are the practical control issues in industry today? What solutions are being found? In this Round Table session, a number of practitioners from various industries such as distilling, paper, IT manufacturing, brewing, vinyl flooring and nuclear power, will outline real control problems, with or without solutions. Each topic will then be discussed by the panel and the audience - this should highlight useful alternatives and areas worth exploring. This session should be of value to engineers in industry, solution providers, researchers and developers.



This Round Table event is arranged by the Electronics, Control and Informatics Section of IEE, Scotland

Special Session ThA7: Funding the Future of Control  
Chair: M. J. Grimble Co-Chair: A.W. Ordys  
Location: Carron 2  
Time: ThA7 14.00 to 15.40

Control and its applications continue to be a thriving engineering and scientific area. Despite being an identifiable discipline it is rarely funded as such. Usually funding for control research and development has to be found in other engineering and application programmes. In Europe, Framework 6 is almost with us and it is necessary for the Control community to make an impact if research support is to emerge. In this special session, representatives of European and national funding bodies will discuss the mechanisms which exist to fund fundamental and applications research in control engineering.

## EXHIBITORS: Hall 1

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