

THE ACT CLUB NEWS

Issue 17

September 1999

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Forthcoming Events for 1999

- *13-17 Sept 1999: Hot Rolling Mill Control and Technology: Int. Training Course, Strathclyde University.*
- *14-17 Sept 1999: Cold Rolling Mill Control and Technology: Int. Training Course, Strathclyde University.*
- *20-23 Sept 1999: Advanced Control Technologies for Power Generation & Distribution: Int. Training Course, Strathclyde University.*
- *30 Sept 1999: New Directions in the Monitoring & Control of Food Manufacturing, Omron Electronics, London (Organised jointly with the London Centre of Technology Transfer).*
- *2 Nov 1999: Introduction to Adams for Control Systems Design, University of Strathclyde (Organised jointly with MDI)*
- *17 Nov 1999: Applications of Advanced Control, Cambridge University*
- *Date to be confirmed: Marine SIG Meeting on Roll Stabilisation, Lloyd's Register of Shipping.*

Welcome to the Summer issue of our ACT Club Newsletter. Over the last year the ACT Club activities have expanded and in the following pages you will notice that there are even more opportunities to attend specialist meetings and training events. The links with Prof. Ron Leigh's group at the University of Brunel are slowly being expanded and he brings new expertise and interests in other industrial sectors, such as the Food and Drinks manufacturing sector.

Technology continues to advance and the role of the control engineer seems to get ever wider. You will find the ACT Club is addressing both the core needs, such as PID Tuning activities, whilst also aggressively promoting future technologies. There is a double page spread (pages 6 and 7) on current ACT Club Research Activities which I hope you will agree has something for everyone. I should also like to remind you that the European Union's research programmes provide funding opportunities for your company and we will keep you informed as they are announced.

We are currently expanding our ACT Club Internet Site. Information about all our future events is now given, including up-to-date agendas, travel and hotel information and you can now even register your attendance on-line. The article on page 9 describes this new facility in more detail.

I hope you enjoy reading the Newsletter. If you have any comments (or criticisms!) we will be delighted to hear from you.

*Prof. Mike Grimble
ACT Club Director*

(continued on page 7)

International Training Courses

At the time of writing, preparations for our imminent Training Courses on Rolling Mills and Power Generation Systems are really hotting up. Here's the latest information:

**Hot Mill Control
and Technology,
13th-17th Sept 1999**

**Improving Control in
Cold Rolling Mills,
14th-17th Sept 1999**

Our Hot and Cold Rolling Mill Training Courses have been a great success, not only with our ACT Club members but also with delegates from overseas companies. This year we have delegates from Australia, Argentina, China, USA, Finland, Spain, Netherlands, Germany and Sweden. So, once again this is a truly International event.

The eagle eyed amongst you will notice that the two courses now coincide and this is to take advantage of some commonality in the lectures being given. This combination will also allow the Hot and Cold delegates to mix and interchange ideas and experiences.

The courses have been well supported by ACT Club members, with delegates and presentations from British Steel, Kvaerner Metals, Alstom and Alcan. Many thanks to you all.

THE ADVANCED CONTROL TECHNOLOGY CLUB

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Forthcoming ACT Club Events

New Directions in the Monitoring and Control of Food Manufacturing Processes, 30th September 1999

This event is the first to be organised by the London Centre for Technology Transfer, and it is being hosted by one of our newest members, Omron Electronics Ltd., in North London. The aim of the meeting is to present recent developments in monitoring and control in food production processes. Particular emphasis will be paid to systems for rapid and intelligent responses to quality problems.

The meeting will include:

- Novel sensors and their integration into an overall quality monitoring system
- Systems approaches for the supervision of food production
- Flexible software for quality management in food production
- Summaries of ongoing research in Universities

The seminar will be of value to attendees from large and small food producers, as well as suppliers of systems and equipment to the food industry. Attendance is *free* and open to non-ACT members but registration is required. This can be done by contacting Pamela Hunter at the London Centre (see page 9 for contact details). The number of places is limited so please register as soon as possible.

This event is being kindly supported by the Ministry of Agriculture, Food and Fisheries (MAFF).

Marine SIG Meeting on Ship Roll Stabilisation, date to be announced

The next ACT Club Marine SIG meeting will be on Ship Roll Stabilisation Systems, as agreed by SIG members at the previous meeting. We have had talks with the Ministry of Defence and various companies to progress a Case Study in this area which will be described. This work will compare different control methods (classical control, LQG, H_{∞} and QFT) for Roll Stabilisation and will use the Type 23 Frigate for the comparisons. Since this Study involves a comparison it will probably be of interest to many of our members, as well as being important to our Marine SIG. As usual, this event will bring together key international speakers and company staff. It will be held at Lloyd's Register of Shipping, in their new London Offices. *Details will follow shortly when the date has been confirmed.*

Introduction to ADAMS for Control Systems Design, 2nd November 1999

As mechanical systems become more complex, control engineering and mechanical engineering tasks need to be closely integrated using the same systems models and equations. The earlier this comes within the design cycle the better the final system will be. Further, errors found late in the design process are costly.

ADAMS, developed by Mechanical Dynamics Int., is the worlds most used package for simulation of mechanical systems and facilitates such an integrated design process. This seminar, jointly organised by the ACT Club and MDI and being held at Strathclyde University, explains how ADAMS can be used and how it links with control engineering tools

(MATLAB, MATRIXx and EASY5). For more information on ADAMS please see our article on page 5.

Applications of Advanced Control, 17th November 1999

Prof. Keith Glover and Dr. Jan Maciejowski at Cambridge University have kindly agreed to host a one day meeting on the Applications of Advanced Control at the University of Cambridge. The arrangements for this meeting are still being finalised but this is one of the leading research groups in Europe and it will provide an excellent opportunity to get an overview of their current activities and contributions from other leading practitioners.

Oil and Gas Meeting, date to be announced

Following our recent Oil and Gas meeting, partly sponsored by the Department of Energy, we received a number of requests for a follow-on meeting. We hope to hold this event in Aberdeen and it will focus on the use of advanced control methods in the Oil and Gas industry. The date has not yet been confirmed but if you would like to contribute to this meeting by way of a presentation please contact Dr. Andrzej Ordys on 0141 548 4204.

We look forward to meeting all our delegates at these events.

Full details of all our events will be circulated to Club members 6-8 weeks prior to events taking place. Details are also being made available on our Internet Site.

Forthcoming ACT Club Events (cont.)

ACT Club Events Planned for 2000

To whet your appetite, here are some of the events we have planned for the future:

- "Economic Justification for Control System Improvements" and Launch Day for London Centre for Technology Transfer, Brunel University
- Plenary Meeting on "System Identification in Practice" to be held early Spring 2000 in Glasgow, with a Steering Group Meeting to be held at Ross Priory
- Non-Linear Predictive Control, Oxford University (Summer 2000)
- Possible ACT Club Workshop linked with the Institute of Measurement and Control's Process Control and Instrumentation 2000 Conference (see page 13)



Recent ACT Club Events

PID Control Workshop, 27th July 1999

Prof. Derek Atherton at University of Sussex hosted a one day meeting on methods of tuning PID Controllers. This meeting was aimed at engineers in industry and covered both the basic principals of the different approaches as well as newer, more theoretical methods. In recent years there have been many new techniques proposed to enable PID Controllers to be set up quickly and to provide performance improvements. This meeting reviewed

these techniques with presentations from renowned experts.

ACT Club Steering Group Meeting, 26th July 1999

The Steering Group meeting took place on the evening prior to the PID Control Workshop in the Stakis Bedford Hotel, Brighton. The ACT Club work programme and future activities and initiatives were discussed and decided, and some of these activities are described within this Newsletter. This meeting was well attended by the usual Steering Group Members, but it was thought that the evening event placed too much of a constraint on time. The next meeting, which will be held at Ross Priory early next year, will revert back to being held on the afternoon prior to a meeting.

Remember, the Steering Group helps determine what the ACT Club does for our members. We would be delighted to hear from anyone who would like a position on the Steering Group. All that is required is one afternoon every six months and opinions as to what we should (or should not) be doing.

Model Based Predictive Control Toolbox, 14th April 1999

The launch of the new Model Based Predictive Control Toolbox from the ACT Club was accompanied by training presentations on the basics of the subject. Prof. Mike Grimble and Dr. Andrzej Ordys gave introductory presentations on the subject and Andy Clegg gave an overview of the new Club Toolbox. This Toolbox includes both GPC and LQGPC algorithms and it can be used both for unconstrained and constrained systems. It also has a static set point optimisation facility. If you were not able to attend this meeting you may receive copies of the

software and the software training manual from Andy Clegg or Lorna.

Process Control SCADA Day, 9th February 1999

The highlight of the meeting at Bailey Automation in Telford was the presentation from Prof. Jacques Richalet on Predictive Control. Prof. Richalet was one of the originators of this subject which has been valuable in process control applications. He also started a company, ADERSA, which supplies software packages to some of the leading international SCADA System vendors. As always Prof. Richalet's talk was very stimulating and thought provoking. His new approach to Predictive Function Control was discussed and the real benefits such techniques can provide were described.

5th Marine SIG Meeting, 8th February 1999

The last Marine SIG meeting was again kindly hosted by Lloyd's Register of Shipping. The main item on the Agenda was the provision of the new ACT Club Ship Motion Simulation Facility which has now been made available for Matlab/Simulink. This new version now includes full 6 Degrees of Freedom models of many vessels, ranging from Tankers to Underwater ROVs. Technical presentations were also made to the Marine SIG and the day concluded with a committee discussion where new activities were agreed.

If any member would like copies of the material distributed at the above meetings then please contact Lorna Fleming at the usual address.

ACT Club Member News

New ACT Club Members

The ACT Club continues to grow and we are pleased to announce that the following companies have recently become new members of the ACT Club.

Alstom have recently joined the ACT Club, primarily to undertake a Case Study on the application of Fault Detection to Gas Turbines.

Kodak became the first company to join through the new London Centre for Technology Transfer. Kodak are primarily concerned with process control for their film production, and as such are heavily involved in Chemical engineering and batch processes.

Mechanical Dynamics is an American company that has developed a software tool (called ADAMS, see the article on the following page) for modelling mechanical systems. Our contact is Charles Glide whom you may know from previous Club meetings.

Prism Technologies have developed a new predictive control package which has been applied very successfully in the power generation industry. Prism are willing to make available their software for Case Studies within the Club.

Omron Electronics Ltd There are many users of Omron Programmable Logic Controllers (PLCs) in industry and we are pleased to welcome them to the Club. Omron are interested in a wide range of applications, ranging from control of manufacturing systems to vision processing.

Rockwell Automation, who produce the Allen Bradley range of PLCs, have decided to join the Club to utilise our expertise on projects and within system developments. Our engineers will visit their site in Milton Keynes to provide consultancy help.

Brown Brothers were approached to provide data and technical support for the MoD Case Study on Ship Stabilisation Systems, as they manufacture the current system fitted to the Type 23 Frigates. Their decision to join was made so that they could also benefit from this Case Study

Roche Products The more long serving of our readers may well recall that Roche were one of the original ACT Club members. They have decided to rejoin to use our consultancy and training services.

Member Training Courses

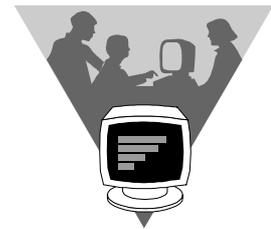
All of our Club members are entitled to two days of training at their company premises free of charge. As you know we have a standard set of courses (see page 14 for full list) that are the most frequently given, and therefore have the best quality set of notes. If you want a training course simply select which course suits you, or give us a call so that we can tailor a course to meet your exact requirements. We do have many separate *training modules* available that may provide just what you want.

This year we have given training courses to:

- Bailey Automation (Control Theory Fundamentals)
- Alcan (Kalman Filtering)
- Ford (Kalman Filtering)
- GEC Marine (Simulation for Control Systems Design)

In the next few months we are going to be giving training courses for Pilkington Optronics, Air Products, Pilkington and Unilever.

We have also been busy developing new course material and we are putting the finishing touches to a new 5-day training course on servomechanisms, which will be given to Pilkington Optronics. Another newly available course (to the ACT Club anyway) is one on Power Systems Quality that is being provided by the London Centre of Technology Transfer (see page 8 for more information). Finally, the ACT Club, together with Wolfram Research, are going to be putting on a Training Course on the symbolic manipulation package Mathematica. This is scheduled for Spring 2000.



Software Packages in the ACT Club

The ACT Club enjoys good links with many Software Companies who provide their software tools for use within Case Studies. This enables companies to see at first hand the benefits that a particular package may offer on real life problems, thereby building confidence in the software prior to buying it.

Recently several new Software Companies have joined the ACT Club, including Wolfram Research (the makers of Mathematica) and Aesop (the makers of Simple++). The latest addition to our list is Mechanical Dynamics International who produce the ADAMS suite of software, which is described on the next page.

Software Packages in the ACT Club (cont.)

What is ADAMS ?

ADAMS adds a new dimension (more specifically a third dimension!) to the modelling and simulation packages that we are familiar with. It bridges the gap between 3D graphical CAD modelling and dynamic systems analysis, thereby providing very visual and realistic simulations. It is primarily intended for mechanical systems and consequently it has found extensive application in the automotive and aerospace industries. However its usefulness extends to a wider range of applications than one would initially realise, for instance the forces and stresses within a steel rolling mill can be modelled very effectively this way. Another application area that ADAMS is used in is the optimisation of work cycle times for manufacturing systems.

The key features of ADAMS include:

- geometrical physical models – built from wireframe, 3D solid models or even from existing CAD databases.
- automatic formulation and solution of the model's equations of motion, allowing realistic simulations to be executed very efficiently.
- powerful animation capabilities are available for visualisation.
- the ability to look at mechanical behaviour, including ranges of motion and potential collisions.
- the ability to simulate applied forces which, for example, can greatly aid the sizing of motors/actuators, determining peak loads etc.

ADAMS enables the design proving process to be extended much further before the need to commit to a physical prototype. This *virtual*

prototyping process can be summarised as follows:

- Build Design: A virtual prototype of the design is built and preliminary feasibility studies performed.
- Design Investigation: Design studies and optimisation can be performed to determine the best design and operating configuration. This can also include looking at the design's sensitivity to tolerances, etc.
- Design Validation: Having selected a design from the investigation exercise, computer simulation results can be compared to test data (if available).
- Design Refinement: Having verified the virtual prototype, modifications to the design can be made if further performance improvements are required. Complex "what-if" scenarios can be carried out.

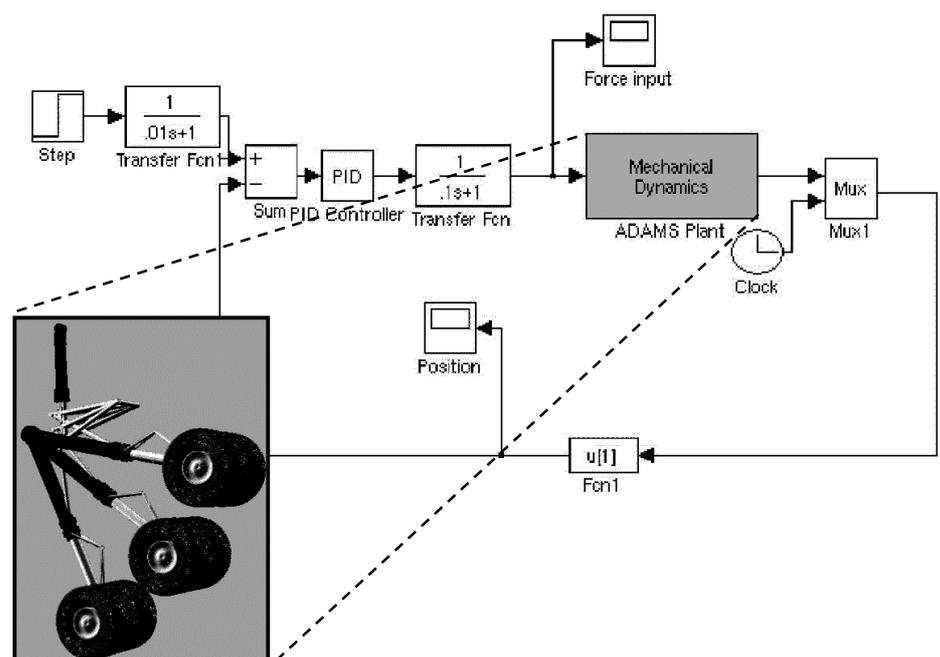
ADAMS has many different software modules allowing a wide variety of configurations. Probably the one of most interest to the ACT Club is the *Controls Module*, which allows ADAMS graphical models to be used seamlessly within Matlab/Simulink, Matrixx/SystemBuild or Easy5 control design packages. This is particularly

useful for complex mechanical systems where the ADAMS graphical model contains all of the complexity within the visual components of the model and the controllers can be designed using a tool that control engineers are familiar with. Other add-on modules available include Finite Element Analysis (FEA), linear systems analysis and flexible bodies.

If any ACT Club member is interested in exploring ADAMS further either through an evaluation or through a Case Study, then please contact Andy Clegg at the ACT Club or Charles Glide at MDI (UK) (cglid@adams.com). For more information on ADAMS please visit the MDI Internet site at <http://www.adams.com>.

Free ADAMS Seminar

To discover more about ADAMS and what it can do, the ACT Club and MDI are jointly organising a one day seminar which will concentrate on the use of ADAMS for control systems design and evaluation. This is scheduled for the 2nd November 1999 and will be held at Strathclyde University. See the ACT Club Internet site for more information and on-line registration.



Current ACT Club Research Activities

Gas Turbine Fault Detection and Isolation

This work has been undertaken for Alstom and carried out by Prof. Ron Patton and his research staff at Hull University. The Case Study has now been completed and the report is being finalised prior to it being distributed to Club members.

Pilkington Automation Study

Andy Clegg has been working closely with the glass maker Pilkington, investigating different control strategies that can be used to automate part of their float bath glass production process. This has involved extensive modelling and validation against plant data. The first phase was successfully trialled earlier this year and now the second phase is underway. Plant trials for the full automation system are planned for early next year which will be a major achievement for all concerned.

Looper Control: A Comparison of QFT and H_∞

The hot strip mill looper/strip tension system has a long history of being used as an example to demonstrate the benefits of multivariable control for hot strip mills. While the benefits of reducing interactions has been shown using H_∞ , there has been little work looking at the robustness of these controllers. This case study approaches the looper problem from a Quantitative Feedback Theory (QFT) and an H_∞ perspective to compare and contrast these design techniques. While H_∞ provides a true optimal and multivariable solution it does not handle parametric uncertainty very well and can result in high order controllers. The QFT method does

handle parametric uncertainty and the controller order can be chosen but it is a manual technique and essentially a single loop design procedure. The case study takes a critical look at these design techniques to highlight the advantages and disadvantages of each.

This Case Study is expected to be completed by late-1999.

Hot Strip Mill Microstructure Control Review

This Case Study, sponsored by Kvaerner Metals, is a literature review of currently applied and new potential techniques to control the microstructure of hot rolled steel and aluminium. The review will include methods of modelling the microstructure. This Case Study is expected to be completed by late-1999.

Power System Analysis: An Investigation of the Prony Method

The operators of high voltage transmission systems seek to ensure the economic, secure and stable despatch of electric power throughout the National Grid. System stability is a condition which has to be monitored and tracked using various online techniques. Prony analysis is a possible additional tool for identifying the dynamical modes within the power system.

This Case Study, sponsored by National Grid, seeks to explore the potential of the Prony method. The power system context is that disturbances in the system can cause the system to oscillate. Some oscillations can lead to the damage of certain equipment components in the system. In the worst situation, the oscillations can cause part of the power system to lose synchronism with the rest of the system. A Prony analysis of the power system signals

will allow the stability status of the dynamical system modes to be assessed. The Prony analysis will use a set of generator swing curves, one curve for each of the 200 machines in the system, and compute the following:

- a list of oscillations modes and associated damping
- a list of magnitudes and phase of the modes

Fin Roll Stabilisation System Design: A Comparison

As described on page 2 the Marine SIG commissioned this Case Study, the main aim of which is to review developments in Fin Roll Stabilisation Control System Design and identify the advantages and possible disadvantages with each. Results using classical control and H_∞ control, developed and tested only a year ago, will be covered. The very promising Quantitative Feedback Theory approach, which provides the robustness as well as simple control design procedure, will also be investigated.

This work is being supported by MoD, Brown Brothers, DERA and Heriot-Watt University research staff.

Steam Mains Supply Header Modelling

Scottish and Southern Energy approached the ACT Club to demonstrate the benefits of modelling within their operations. At the design stage for Combined Heat and Power Plants (CHPs) the amount and rate of steam supply required to meet end-user demands can only be estimated. The accuracy of this estimate determines how well the installed CHP plant is specified. This allows tighter supply agreements and minimises the risk of failure to supply the process requirements. This is also very

important when developing bids against tender specifications.

This Case Study is intended to provide Scottish & Southern Energy with an introduction to the modelling of Steam Supply Systems and to explore the techniques, tools and benefits that this can bring. The Club aims to build a suite of models that can be connected together with minimal knowledge of the underlying mathematical model, thereby resulting in a tool that their engineers can use.

Economic Auditing of Process Plants

Interest from one of our Club members in the petrochemical area has led us to develop a new service for ACT Club members. The idea is to develop formal procedures for undertaking an economic audit of process plant. The aim is to try to quantify the possible cost savings which can be made by upgrading systems using new software or hardware tools.

The results of the study will be made available in a report that will indicate the merits of different commercial products and provide full information on contacts and possible advantages of their particular system. Clearly such projects give an opportunity for other Club members to become involved, remembering that the objective is to give a non biased and authoritative assessment.

An information sheet has been produced on this service and can be obtained from the ACT Club.

Process Control Research

Members will be pleased to know that Damien Uduehi is undertaking a PhD Programme in the Industrial Control Centre at Strathclyde University and will be participating in case studies for the ACT Club. He has a particular interest in the development of

Optimisation Algorithms for Process Plant and in Predictive Control Systems. We are very interested in having feedback from members on possible Process Control problems that he may investigate that might stretch the new regulating loop designs or predictive supervisory systems he is developing.

New PID Tuning Methods

A new technique has been developed, termed restricted structure optimal control where the PID Controller coefficients can, for example, be found to minimise a cost function. In fact this new technique can find the optimal coefficients of any reduced order controller. The main advantage should be that it will de-skill the time consuming task of tuning controllers.

This work was will initially presented to Club members at the recent PID meeting. However, it is currently being re-worked into an Educational Note to make it more accessible to industrial users. This is being carried out by Mike Grimble in conjunction with British Steel (Roy Nicholls) who will work to help to make this a more useful and understandable document.

The report will cover the optimal PID tuning method applied to a system described by a number of models (which can be for either temporal variations or system nonlinearities). The suggested application area is Hot Strip Rolling Mills.

If there is sufficient interest from members a Matlab toolbox will be constructed to make available this advanced tuning method together with more traditional Ziegler-Nichols techniques. For further information on progress please contact Mike Grimble.



Other Forthcoming Reports

- Survey of Signal Processing Techniques: being carried out for Lloyds Register of Shipping.
- Industrial Process Control: authored by Prof. Mike Johnson.
- Neural Networks Applications in Marine Systems: a very well written and informative report.
- Problems and procedures for Multivariable process control
- Mathematica Application Study

If any ACT Club member would like additional copies of any of our reports then please get in touch at the usual address.

A full list of ACT Club Reports can be found on the last two pages of this newsletter.

International Training Courses (cont.)

Advanced Control Technologies for Power Generation and Distribution, 20th-23rd Sept 1999

This Training Course will be very well attended by ACT Club members, though we have not got the balance right to attract the same number of international delegates that the Rolling Mills Courses have. We hope to optimise it for next year.

The agenda looks very interesting and useful with key presentations from Scottish Power, British Energy, Scottish & Southern Energy and National Grid. We also have some software companies demonstrating their latest developments, these include COGSYS and Prism Technologies.

London Centre for Technology Transfer

The London Centre for Technology Transfer is a new organisation set up by Prof. Ron Leigh at Brunel University, which is closely linked with the Advanced Control Technology Club. We have a mutual agreement whereby any companies who join the London Centre gain access to the general awareness services of the larger ACT Club. Therefore members of the London Centre are treated as full ACT Club members, but the local, company specific services are provided by Ron Leigh and his team.

Meetings and Seminars

The first meeting organised by the LCTT is a **free** seminar for the food industry entitled "New Directions in the Monitoring and Control of Food Manufacturing Processes" on 30th September 1999. More details are given on page 2 and on the ACT Club Internet site. If there is sufficient interest from food related companies, a Special Interest Group for the Food and Beverage Industries will be set up. This will be discussed with the attendees during the above meeting.

Another event being planned by the LCTT is one on Economic Justification of Control System Improvements. This will look at how economic benefits of control systems improvements can be estimated and used to justify implementation projects. The event will hopefully bring together ideas for estimating improvements, real world cost benefit savings and benchmarking. It should be very useful for anybody involved in industrial control systems.

New Training Courses

The LCTT can provide a one day introductory course on power supply quality to Club members.

In recent years there has been a considerable increase in non-linear electrical loads. In particular power inverters, rectifiers and distributed loads, such as computers, monitors and lighting, are extensively used. All of these are very unattractive since they generate harmonics which degrade the power supply, through increased interference and running costs and decreased reliability. Often the 50 Hz signal is almost invisible amongst the harmonics and the balance of the three phases may be threatened. Active filtering is often needed to satisfy EU regulations.

This course has been designed to help Companies understand and cope with all aspects of power quality problems and will address:

- The main causes of power quality problems.
- Effects of current harmonics on electrical supplies and equipment in commercial buildings and power distribution networks.
- Potential solutions, including active filters.

This course will be of interest to facilities managers, equipment manufacturers, power utilities and the building services industry. Consultants and academics wishing to update and expand their knowledge in this field may also benefit from the course. We expect to run this course in Winter 1999. Please contact the LCTT to indicate your interest.

Opportunities for Collaboration

Systems for Rapid Proactive Response to Quality Problems in Food Manufacture

The LCTT is interested in hearing from anybody who is interested in collaborating in the above project, under the "Advanced and Hygienic Food Manufacturing" LINK

Programme, that is currently being developed by Brunel and Reading Universities and industrial partners.

The finely balanced profitability of a modern high-speed food processing plant can be significantly disrupted by even a minor contamination or an out of specification run of product. In the limit this can result in product-recall, with its associated huge costs and adverse publicity. Assuming that such problems are inevitable even in the best of plants, the main issues to be addressed are:

- rapid and precise identification and reporting on the nature, seriousness and extent of the problem
- search backwards in the process to locate the problem source
- search forwards in the process to delineate any product that may be effected

The project will not only address the above issues but will at the same time offer improved feedback of quality measures. A generic solution will be developed that will use innovative rapid data interpretation techniques and model-based methods to give sophisticated early warning of developing problems, together with both forward and backwards delineation of the extent of the problem. A working prototype will be developed to demonstrate the systems effectiveness and integration with existing plant control systems.

If you are a food manufacturer or a supplier to the food industry and would like to be involved in this please contact Prof. Ron Leigh as soon as possible.



London Centre for Technology Transfer (cont.)

Do you know what a Teaching Company Scheme might offer

Did you know that the Teaching Company Scheme (TCS) can pay up to 60% of the costs of a no-frills two-year programme to improve efficiency within SMEs. We are enthusiastic about these schemes and invite you to find out more.

LCTT contact details:

Main Point of Contact:

Prof. Ron Leigh

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Pamela Hunter (temporary)

Tel.: 01895 274000 ext. 2822
Email: pamela.hunter@brunel.ac.uk



ACT Club WWW Site

We have been hard at work over the Summer improving our Internet Site to make it more useful to our Members. For instance, you can now access complete details for all our ACT Club events, including up-to-date agendas, travel and hotel information and on-line registration. Just follow the links from our "ACT Club Events" WWW Page. Please try to use this service as we will only continue to support this if it is being used.

Another way in which we are increasing the usefulness of our Internet Site is by creating a Resource Centre of industrial control related resources, both within the ACT Club and on the Internet. This should establish the ACT Club Internet Site as a key resource for any engineers wanting to find out more about either particular control techniques or specific applications. This Resource Centre is now on-line, but it is still undergoing development. We will be continually adding to the site and expanding it to cover any areas in which our members are interested.

Finally, we are also in the process of making the Club reports and software available over the Internet so that members can access them as and when needed. We currently have a sample Educational Note that can be downloaded from our Site, and this will be extended if it proves popular. These download areas will be password protected so that only ACT Club members can download these items. We will be writing (or emailing!) to all our members when this service comes on-line.

The ACT Club Internet Site is attracting many people, but we hope these developments will make it a useful place for control engineers to start using the Internet. This development is a continuous process and we would be delighted to receive any comments and ideas about how we can improve it to make it even better.

Main ACT Club Page:
<http://isc.eee.strath.ac.uk/actclub.html>
ACT Club Events:
http://isc.eee.strath.ac.uk/act_event.html
Resource Centre:
http://isc.eee.strath.ac.uk/resource_centre

The screenshot shows a Netscape browser window displaying the ACT Club website. The browser's address bar shows the URL <http://isc.eee.strath.ac.uk/actclub.html>. The website has a dark background with a light-colored sine wave graphic at the top. The main heading is "Advanced Control Technology Club". Below this, there are navigation links: "[Back] [Next]". A "Contents" menu is visible on the left side, listing: Home Page, Advanced Control, Knowledge Engineering, Business Process Modelling, ACT Club, New (with a star icon), About ACT, Activities, Facilities, Members, and Deliverables. The main content area features a "HOT NEWS!!!" section with the following text: "Industrial Training Courses" (with details about Hot Rolling Mills, Cold Rolling Mills, and Power Generation and Distribution), "ADAMS Modelling and Simulation Package" (with details about MDI's 3D graphical modelling tool), and "Full Details and On-line Registration for ACT Club Meetings" (with a link to full details).

CONFERENCE NEWS

Florida in Control

The 37th IEEE Conference on Decision and Control was held in Tampa, Florida during December. There were around 1000 attendees and the highlight was the award of the very prestigious IEEE Control Systems Award to Prof. Jan C. Willems (Groningen University) for his contributions to control theory and for leadership in systems research. The Bode Lecture prize went to Prof. Boyd Pearson (Brown University) whilst the Bode Award Lecturer was Prof. Graham Goodwin (Newcastle University, NSW).

One of the innovations in this years conference was to have a plenary debate, and this was between Lotfi Zadeh (Berkeley) and Michael Athans (MIT). They do of course have well known positions in leading the debate for and against the use of fuzzy control. Michael Athans, who strongly supports the use of model based control methods, had mischievously entitled his debating paper "Why I despise Fuzzy Feedback Control". Michael went through various debating points with some deliberately hard hitting, but good humour, responses clearly to provoke an interesting discussion:

Debating point: I like fuzzy logic, especially for applications involving man-machine interactions.

Athans' Response: Fuzzy control represent inferior engineering practice, often by people that have never bothered to learn control theory and design.

Prof. Athans believes a fundamental flaw in Fuzzy Control is that the assumption that humans are good controllers is wrong. Where Fuzzy Control is successful, most of the applications are simple first-order

processes that can easily be controlled using PID. He also pointed to the obvious short comings on multivariable systems, where no human-being is able to deal effectively with the multivariable or combinatorial problems. He also cited the latest developments in non-linear control systems, where there are attempts to approximate non-linear systems by a number of linear time-invariant models and to then use fuzzy functions to interpolate between them. In practice it is very difficult to define such functions and the results are very disappointing, since they don't specifically address the important issues of robustness.

In his concluding remarks Michael Athans stated that mathematical control theory offers a powerful methodology for designing both single-input, single-output and multivariable, optimal and high performance feedback control systems. There is of course a need for an extensive theoretical knowledge and also quantitative modelling of the plant is essential. The result is often a high gain, high bandwidth and high performance design. On the other hand he believed that fuzzy control is only suitable for trivial control problems, requiring low accuracy. Fuzzy techniques, he claims, employs an empirical, ad hoc approach to controller design which results in low gain, low bandwidth and hence low performance designs. Athans also stated that fuzzy control is a parasitic technology; they simply implement trivial interpolations of control strategies obtained by other means.

Prof. Athans' final points were that Prof. Zadeh should communicate to his disciples the sorry state of affairs in fuzzy feedback control and tell them shape up. The above rather hard-hitting points were all of course made "tongue and cheek" and were aimed at provoking an interesting

discussion. However, Athans was serious in his claims that fuzzy control has failed to encapsulate uncertainty in a way significantly different to traditional theory.

Prof. Zadeh was naturally put on the defensive from the start of his presentation. Rather modestly he explained that fuzzy control is not a replacement for, nor better than, so called conventional crisp control techniques. He noted that humans can park a car without the same type of measurements and computations that model based techniques would need, so there must be something in the fuzzy concept which cannot be captured in conventional control methods. Further, he stated that humans use words to compress data, a key element of fuzzy logic, which cannot really be dealt within conventional control methods.

One of Zadeh's main arguments is that there is tremendous activity and interest in the subject of fuzzy control and that this very clearly justified the need for this technology, and the evidence was of course that the debate itself was taking place. He noted that a recent article in the New York Times that stated that the new Volkswagen Beetles utilised a fuzzy logic controller (designed using the Mamdani technique and included seven logical rules) in its automatic transmission system. He also gave numerous other milestone applications, including a heat exchanger control problem way back in 1977.

Zadeh returned to the claim that control is driven by information obtained from both measurements (crisp data) and perception based (fuzzy). He noted that there is no way to manipulate such perceptions in standard control theories and that one of the major contributions of fuzzy control was its ability to handle.

Conference News (cont.)

perceptions. He went on to state that this made fuzzy control a generalisation of crisp control, in the same way that nonlinear control is a generalisation of linear control. His conclusions were that the principle contribution of fuzzy logic is as a methodology of computing with words, which in turn provides the basis for a computational theory of perceptions.

After the two main protagonists had completed their presentation, other panel members gave their ideas. Karl Astrom raised the question of whether high quality systems can be designed without knowing differential or difference equations. In response Lotfi Zadeh believed that techniques like LQG control were very narrow methodologies whereas fuzzy control has a much broader appeal for supervisory systems and the like. Michael Athans re-iterated his view that fuzzy control was only suitable for simple controllers without tight specifications.

A referee might have concluded that Athans did effectively demonstrate that there are real weaknesses in using fuzzy control for some applications. However, this was not a knockout blow since Zadeh's defence was that there is a real need for this technique in certain classes of problems. This story will continue and we all look forward to the next bout.

Back to the main conference, which included a number of invited sessions. Prof. Michael Sebek (Czech Academy of Sciences) organised one concerning the industrial applications of polynomial methods. One of the main features of this session was the new Matlab polynomial systems toolbox (PolyX) which was demonstrated. The toolbox provides all of the polynomial manipulation routines that are needed for a very wide range of linear system

design problems. Prof. Neil Munro (UMIST) described a project on control system analysis and design using Mathematica, which provides an alternative route to solving such polynomial based problems.

There remains considerable interest in systems with transport delays and Prof. Derek Atherton (Sussex University) described a new Smith Predictor and controller for unstable processes with time-delays. Minyue Fu (University of Newcastle, NSW) described a non-linear modelling approach to the sugar cane crushing process problem. Andrzej Ordys (Strathclyde University) described recent work on State-Space Generalised Predictive Control. There remains considerable interest in H_∞ control and estimation methods. Shaked (Tel Aviv University) considered H_∞ prediction and smoothing problems for discrete time systems and employed the so-called J -spectral factorisation approach.

American Control Becomes More Practical

The 1999 American Control Conference (ACC) was held in San Diego this June and attracted over 1,000 delegates. The ACC has always been more practical than the IEEE CDC conference, but this year the sessions seem to have been even more relevant to industry.

The first plenary presentation was by Prof. Bob Skelton (University of California) who stated that systems design is relatively neglected in universities to the detriment of industry. His contention was that universities teach component technologies very well but ignore the larger picture. He cited Michael Faraday's advice: *begin with the whole, then construct the parts*. The main theme of his talk was that plants and controllers should be designed jointly, and that attention should be

focussed on the total system rather than on individual subsystems. This has of course been appreciated in the process industries for many years. However, he cited aerospace examples where this has not been the case.

He went on to discuss the problems of modelling, saying that an ounce of improvement in modelling is worth a ton of robust control. He noted that the size of modelling error is not continuous when going from components to the total system. In general, good component models do not necessarily imply good overall system models. Finally, he quoted Howard Garner (Harvard) regarding the mysteries of understanding data, which certainly bears repeating:

*Data is not Information.
Information is not Knowledge
Knowledge is not Understanding
Understanding is not Wisdom*

I was tempted to add wisdom is not data, but resisted, on the basis that this could lead to a limit cycle.

One of the most valuable innovations at this year's ACC was the increased emphasis on Tutorial Sessions. Just how effective these are was evident from the Tutorial on Neural Networks for Control, organised by Martin Hagan (Oklahoma State University), which attracted over 100 people. Hagan's first paper provided a very simple introduction to the subject of neural networks, including the benefits and difficulties. He considered topics such as regularisation, training errors, over fitting, validation and explained how neural networks are valuable for interpolation but not for extrapolation, where data is poor. He also described various ideas in non-linear control using neural networks and a number of different methods were presented. This is of course a little controversial since the behaviour of neural networks is not always very predictable.

Conference News (cont.)

The industrial contributors to this Neural network session were equally effective. Salim Jaliwala (Cummins Engine Company) described the use of neural networks for intelligent control for a range of different applications, including diesel engines. He discussed autotuning, using genetic algorithms and the use of neural networks for detecting cylinder misfire signatures in diesel engines. Edward Wilson (SAI International) considered the use of neural networks in the metals processing industry, specifically for control of large arc furnaces. The system provides savings of up to \$1 million per year for an investment of about \$300,000, and currently they have installed about 40 such schemes around the world. More generally, he said that neural network based systems are greatly dependent on the availability of good data and that real world noise can cause problems. He also claimed that the choice of architecture for the neural network was more important than the type chosen. Finally, he strongly recommended the careful selection of applications where neural networks are appropriate. Further contribution to this section were by Mark Motter (NASA Langley) on the control of transonic tunnels and by Roger Schultz (Halberton Energy Services) for transducer calibration and signal processing.

One of the other tutorial sessions involved statistical process control and controller performance monitoring. A contribution by Man Hugo (Control Arts) on performance assessment of DMC controllers was particularly well attended.

The more practical nature of the ACC lead to the two session on PID controller tuning organised by Johnson (Strathclyde) and Huang (Taiwan) being very popular. Andre Desbiens

(University of Laval) discussed the design of multivariable PID controllers using the selection of input-output pairings and techniques such as the Dynamic Gain Array. Thomas McAvoy (University of Maryland) considered the synthesis of plant wide control systems using PID controllers and Yong Zhang (National University of Singapore) discussed autotuning methods. Prof. Lazlo Kevizky (Hungarian Academy of Sciences) discussed an adaptive scheme for PID autotuning and the session ended with a very lively debate on restricted structure optimal control law design.

Another session was concerned with disc drive control problems. The application of Quantitative Feedback Theory in disk drive controls was considered by Gerald Hearn (Strathclyde). A multiprocessor H_∞ disk drive application was discussed by Marco Deltori (Delft University of Technology). Sang-Eun Back (Samsung Advanced Institute of Technology) considered the design of multi-rate estimators and their application to disc drive systems. There are of course consumer, industrial and military applications of disc drive systems and they all require high performance robust control systems. This session demonstrated not only the interest in this subject but the advances made to provide improved tracking, even though manufacturing tolerances are reduced and larger disturbances are being imposed upon systems.

The interest in fault detection systems continues and Henrik Niemann (Technical University of Denmark) discussed an observer based approach. He considered the following questions. *When is it possible to get almost exact fault detection - Which faults can be detected/isolated exactly (or almost) -* and so on. This type of problem is known as the "fundamental problem" in fault detection due to Massoumnia. Domenico Mignone (ETH Swiss

Federal Institute of Technology) discussed their work on moving horizon estimation for hybrid systems and fault detection. The development of a more practical theory for hybrid systems seems to be one of the strong areas of research and Prof. Manfred Morari's Group at ETH is in the forefront of the process. His work on fault isolation was aimed at determining when false alarms are likely methods to determine the cause for these false alarms.

The meeting included a number of sessions on automobile control with one session on hardware-in-the-loop being particularly interesting. Martin Schmidt (Damstadt University of Technology) discussed the use of model based torque controller for engine test rigs. Control engineering support for automotive applications appears to be increasingly important.

Sekhar Tatikonda (MIT) considered the control of LQG systems under communication constraints. In his very novel contribution he considered the plant to be part of the communications channel. The perspective he brought to LQG control was novel and is very likely to be a subject for further development.

Dimenico Famularo (University of Dela Calibra) considered the use of global optimisation methods for *fixed* order controller design. The draw back with the approach seemed to be the numerical complexity due to dimensionality but it was one of the number of contributions in this area which is becoming of increasing importance.

Interest in the compensation of systems with significant transport delays continues. Time delay compensation in H_∞ control by Grant Fisher and colleagues was presented using a conventional state-space approach. The use of future setpoint information in H_∞ design was

Conference News (cont.)

described by Charles Barb (University of Florida).

There also seems to be a growing number of papers on induction motor control and Hassan Khalil (Michigan State University) and Gerardo Ramirez (National University of Mexico) both described robust and adaptive methods of dealing with the uncertainties and nonlinearity in induction motor speed control.

There was a session that was devoted entirely to descriptor systems, which enables dynamic and static equations to be mixed. This subject is very useful for certain industrial problems.

Process Control and Instrumentation 2000

The Institute of Measurement and Control are to introduce a new series of conferences focusing on process control. The first such conference, *Process Control and Instrumentation 2000*, will be held at the University of Strathclyde on 24-26th July, 2000. Many control engineering conferences tend to be rather theoretical but this particular event will concentrate on the practical issues of instrumentation systems, advanced and classical control, system simulation and modelling and plant identification.

A new innovation at this conference is the introduction of specialised tutorial workshops, focussing on particular industrial topics or introducing new technologies. If you or your company would like to be involved in one of these self-contained events then please contact Prof. Mike Grimble.

Industrial Control Centre News

Royal Society of Edinburgh Award

Prof. Mike Grimble has recently been elected a fellow of the Royal Society of Edinburgh. Scotland has a long tradition of engineering excellence and the Royal Society includes amongst its members the most distinguished scientists and engineers over many years. Fellows are elected by the membership and it is believed that this much appreciated honour is due in great measure to Mike Grimble's work in bridging the industrial/academic divide through initiatives like the ACT Club.

British Energy Lectureship

British Energy are kindly supporting a lectureship within the Industrial Control Centre. One of the main areas of work for the ICC is the development of safe and reliable control systems, which is of particular importance to the nuclear industry.

The interest in supporting such a post stemmed from a visit by Dr. Robin Jeffrey who is the Deputy Chairman of British Energy and a graduate of Strathclyde University. After the visit, Mr. David Anderson who is the Engineering Director of British Energy supported the initiative and Dr. Andrzej Ordys has now been appointed to the post. Some of you may know Andrzej who has worked for the Club in the past, and he continues to be involved being the co-ordinator of our fledgling Energy SIG. Within the ICC Andrzej has particular responsibility for managing European Union networks and it is now the intention for him to forge very close links with British Energy.

By supporting an industrial lectureship companies can achieve very close links with the University that should enable courses to become more industrially relevant and research to be stimulated by industrial needs. Both the University and Department were most grateful for the support provided by British Energy.

EUROPOLY Network

Those who think EUROPOLY is a new European Union designation for a standard parrot would be mistaken. It is, however, a new interdisciplinary Network of Excellence (sponsored by the EU) to promote the use of polynomial methods for frequency domain systems analysis. Polynomial methods are modern industrial design techniques for complex multivariable systems, signals and processes based on manipulations with polynomials, polynomial matrices, and other similar objects. Invented, developed and applied in Europe, the methods are considered typically European. The Industrial Control Centre is a member of the EUROPOLY Network.

The members of the Network have developed a Matlab based polynomial package (PolyX) which can be used for frequency domain controller design. There are a series of workshops in different EU member states, and the next one will be held at Twente University, in the Netherlands, 16th October, 1999. A regular Newsletter is published to inform Network members of activities. An interactive email discussion group has also been set-up to provide a forum for informal discussion and information exchange.

Any companies or research groups willing to contribute to EUROPOLY are welcome to join the Network as External Members. Further details of the Network can be obtained by visiting the EUROPOLY Internet site (<http://www.utia.cas.cz/europoly>).

ACT CLUB TRAINING COURSES

The training courses described below are standard courses available through your company's membership of the ACT Club. The courses can be focused on your specific needs and applications and individual modules from different courses can be mixed to form a client specific course. In addition the courses can be aimed at technician to research engineer level.

Should your company require course modules which are not listed then our relationship with Strathclyde University can be exploited to ensure that tuition on virtually any control technique can be provided. Courses are generally run as and when required and can be conducted on your own premises or here in Glasgow.

All of our courses are eligible for CPD (Continuing Professional Development) as recognised by the major Engineering Institutes.

Course 1: Classical Control and PID Tuning Methods (1 Day)

The course covers basic concepts of classical control and provides practical guidelines in implementation and tuning of PID controllers. The course is aimed at technician level.

Course 2: Predictive Control (1 Day)

The course provides overview of Predictive Control techniques and



then gives guidelines for analysis and tuning of predictive controllers.

Course 3: Control Theory Fundamentals (2 Days)

The course provides training on an engineering level in Classical Control Theory and Control System Design. The course presents frequency and time domain analysis of linear control systems. The PID controller and tuning methods are also covered.

This is the most popular training course that we offer. It is especially useful to those engineers who may not have had specific theory teaching during their electrical or mechanical engineering degrees. It also provides an excellent refresher course in basic control engineering for practising engineers.

Course 4: Overview of Modern Control Design Techniques (2 Days)

The course provides an overview of modern control design techniques ranging from Robust (H_∞) to Predictive Control, Adaptive Control and Fuzzy Logic Control.

Course 5: MATRIX_x (3 Days)

This is a basic training course for control design and simulation using the MATRIX_x family of analysis, simulation and realisation tools. This results orientated course provides knowledge and skills that can be applied immediately.

Course 6: Control Fundamentals for Engineers (6 Days)

The course starts from basic concepts of signals, systems and computer simulation. The course covers Classical Control Systems Design Methods, PID control, Multivariable Control design, Robust Control techniques, Adaptive Control, Predictive Control and Optimal Control. The course is focused on use of advanced computer tools to control system design and simulation. The theoretical material is supported with numerous tutorial examples in MATRIX_x.

Course 7: Kalman Filtering (1 Day)

This course gives a detailed description of Kalman Filter theory and implementation.

Course 8: System Identification and Self-tuning control (1 Day)

This course presents methods for System Identification and design of Self-tuning Controllers.

Course 9: Robust Controller Design (2 Days)

The basic concepts of robustness of control system are introduced. Those are analysed using classical design methods (for both single-input single-output systems and multivariable systems) and compared with modern (H_∞) approach. Available computer design packages are discussed.

ACT CLUB SERVICES TO MEMBERS

THE ADVANCED CONTROL TECHNOLOGY CLUB

The ACT Club provides its members with access to a very wide range of control technologies. This is accomplished through the various services that are listed below and which are *FREE* to members of the ACT Club.

- Regular Plenary meetings, training courses and awareness days on both basic and advanced subjects. *Typically 2-3 per annum, held centrally.*
- An annual training course at the company premises. This can be selected from our standard range covering virtually all topics in control, or tailored to meet your exact requirements. *Typically 1-2 days duration.*
- Case Studies proposed by members are undertaken to investigate the usefulness of new technologies. *Typically 3-4 case studies are undertaken per annum.*
- Special Interest Groups (SIGs) that focus our efforts onto particular sectors of industry. *Typically 1-2 meetings per annum.*
- Annual visits to provide consultancy advice at company premises.
- Instant access to consultants is available over the telephone, fax or email.
- The ACT Club's own range of user-friendly software packages and toolboxes designed to make advanced control more accessible.
- Access to commercial software and hardware rapid prototyping systems.
- Detailed technical reports and easy to understand educational notes.
- Regular conference reports from most of the major events worldwide on latest technology and results.
- Regular mailings and newsletters.

Case Studies

Case Studies investigate the applicability of advanced control technologies to specific industrial problems as proposed by the ACT Club members. These studies usually take the form of a 1-3 month study, which can be either simulation based or use real hardware to interface directly to the members' plant.

The following Case Studies have been carried out and the associated reports can be made available to Club members.

ROLLS ROYCE: Control of a Gas Turbine Engine (CS01/1992)

BRITISH GAS: Self-Tuning Control of a Furnace Temperature (CS02/1992)

BRITISH AEROSPACE: Pitch Control of a Generic Canard Delta Aircraft (CS03/1992)

BRITISH STEEL: Control of Reheat Furnace (CS04/1993)

BRITISH STEEL: Gauge Control for Cold Rolling (CS05/1993)

ROCHE PRODUCTS: Non-linear Model Based Control for pH (CS06/1993)

MARINE SIG: Design of Robust Ship Positioning Systems and Advantages of Feedforward/ Feedback Control (CS07/1995)

BRITISH AEROSPACE: Classical versus Modern Control Design Methods for Safety Critical Control Engineering Practice (CS08/1995)

BRITISH STEEL: Multivariable Decoupling Control of Collector Main Pressure on Coke Ovens (CS09/1995)

ROCHE PRODUCTS: Roche Vitamin C Modelling Report (CS10/1995)

BRITISH GAS: British Gas Maintenance Reduction (CS11/1996)

BRITISH PETROLEUM: Introduction to Predictive Control with Application to a Hydrogen Reformer (CS12/1996)

T&N TECHNOLOGY: Gauge Control of Cold Rolling Mill (CS13/1996)

ROYAL ORDNANCE: An Operational Planning Tool for the Royal Ordnance Nitro-Cellulose Process (CS14/1995)

BARR & STROUD: Control of a High Resolution Laser Scanner (CS15/1996)

MARINE SIG: Implementation Problems and Design of Ship Autopilots (CS16/1996)

MARINE SIG: Advanced and Classical Control of Non-linear Ship Positioning Systems (CS17/1996)

ROYAL ORDNANCE: Expert System Based Training Simulator: Picrite Process Application (CS18/1997)

UNILEVER RESEARCH: Supply Chain Management Into The Year 2000 (CS19/1998)

Technical Reports

Technical Reports provide a detailed theoretical description of specific advanced control techniques. These notes are written to be a concise and complete source of information that

any engineer working in that particular field will find invaluable.

The following list gives all the ACT Club Technical Reports:

Application of Expert Systems in Industrial control (*ACT Report 1/1990*)

A Tutorial of Polynomial LQG/ H_∞ Optimal Control for Industrial Users (*ACT Report 2/1990*)

A Tutorial of Digital LQG and H_∞ Self-Tuning Control for Industrial Applications (*ACT Report 3/1990*)

μ -Analysis and Synthesis (An overview of an Optimisation Based Method for Multivariable Control Design) (*ACT Club Report 4/1990*)

Weighting Functions in H_∞ Control (*ACT Report 5/1991*)

Introduction to Non-linear Self Tuning Control (*ACT Report 6/1992*)

An Introduction to the Control of Non-linear Processes (*ACT Report 7/1993*)

Mathematical Notations and Glossary (*TR07/1993*)

On the Performance of Generic Model Control (*TR09/1993*)

An introduction to Neural Networks (*TR10/1994*)

Long Range Predictive Control: A Review (*TR11/1994*)

Introduction to the Benefits of Controller with Several Degrees of Freedom and the Use of Feedforward Control (*TR12/1995*)

Applications of Fuzzy Logic Control (*TR13/1995*)

Tutorial Introduction to L_1 Analysis and Synthesis (*TR14/1996*)

Comparison of the Design of a Marine Autopilot using H_∞ Design and Quantitative Feedback Theory (*TR15/1997*)

Advances in Autotune Methods (*TR16/1998*)

Fibre Optics and their use in Field Trials Measurements Systems (*TR17/1999*)

Educational Notes

Educational Notes are a simple introduction to the various control subject areas that are becoming increasingly prominent and relevant to industry. These introductory texts are aimed at engineers with no prior knowledge of the subject described and provide a basic understanding of the techniques involved.

The following list gives all the ACT Club Educational Notes:

What is H_∞ Optimal Control ? (*EN01/1990*)

What is Robustness ? (*EN02/1990*)

Typical Robust Control Design Problems ? (*EN03/1990*)

What is Self-Tuning Control ? (*EN04/1990*)

A Note on Smith Predictor for the Control Process Plants with Significant Transport Delays (*EN05/1993*)

Tutorial on Variable Structure Control for Industrial Users (*EN06/1995*)

Simple Introduction to Kalman Filtering (*EN07/1996*)

An Introduction to Discrete Event Simulation (*EN08/1997*)

Mathematica and the Control System Professional (*EN09/1998*)

Tutorial Introduction to Quantitative Feedback Theory (*EN10/1998*)

ACT Club Software

The software packages listed below provide intuitive user friendly tools for many of the common control design laws. Comprehensive manuals and examples are provided and complementary training courses often exists.

H_∞ Robust Control Toolbox for MATLAB

Robust H_2 Feedback/Feedforward Control Design Toolbox for MATLAB (Polynomial Approach)

Multivariable Robust Control Toolbox for MATLAB

Self-Tuning Control Software

Nonlinear Self-Tuning Control Software

EASY_KIT Toolbox for MATLAB

4 DoF Non-linear Ship Modelling Package for MATRIXx

6 DoF Marine Vehicles Simulation and Control Package for Matlab

Model-Based Predictive Control Toolbox for Matlab/Simulink

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