THE ACT CLUB NEWS

Issue 16   **December 1998**

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Welcome to this bumper issue of the *Advanced Control Technology Club News*. It is filled with details of our forthcoming events and activities, as well as the usual conference reports and other news articles.

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

Andy Clegg
ACT Club Manager

Forthcoming Events for ACT Club Members

5th Marine SIG Meeting 8th February 1999

The next Marine Special Interest Group Meeting will be held on 8th February 1999 at Lloyd's Register of Shipping in Croydon. The theme of the meeting will be Fault Monitoring and System Integration with guest speakers describing recent developments in these areas.

The ACT Club will report on the Lloyd's study into the use of Fibre Optic Cabling and also launch the updated *Ship Modelling and Simulation* package which now works in Matlab/Simulink.

Process Control and SCADA Systems Meeting, 9th February 1999

Bailey Automation in Telford is hosting this event which will bring together speakers from both academia and industry. It should be a very interesting day especially as we have the renowned researcher *Prof. Jacques Richalet*, who will give the key presentation, entitled "Industrial Applications of PFC Predictive Control".

Other speakers from the Oil and Gas Industry and Systems Suppliers perspective will make this a very well rounded day. A tour around Bailey Automation is also included.

Predictive Control Toolbox Launch Event 14th April 1999

The Industrial Control Centre has developed a *Predictive Control Toolbox*, which is being made available to Club members. The main purpose of the Toolbox is to enable engineers to try out Model Based Predictive Control without the need to understand the underlying theory and algorithms. The Toolbox makes extensive use of Graphical User Interfaces to guide the user through the design process. The algorithms implemented in the toolbox, including current state-of-the-art techniques, are accessible if required. A full description of the Toolbox and its features can be found on Page 2.

The official launch of the Predictive Control Toolbox will be on 14th April 1999 at the University of Strathclyde. The programme for the day will consist of:

- Theoretical introduction to Predictive Control
- Detailed presentation of the Toolbox capabilities
- Hands-on sessions.

Interested Club members can request a beta version of the Toolbox for evaluation. If you are interested please contact Andy Clegg.

Events for 1999:

- 5th Marine SIG Meeting, Croydon, *8th February*
- Process Control & SCADA Systems, Telford, *9th February*
- Energy, Oil & Gas Event, Aberdeen, *March (tbc)*
- Predictive Control Toolbox Launch, Glasgow, *14th April*
- Steering Group Meeting, *19th May (evening)*
- PID Control Day, University of Sussex, *20th May*
- Applications of Advanced Control, Cambridge University, *mid-September (tbc)*

- Improving the Quality of Control in Cold Rolling Mills Training Course, *October (tbc)*

Energy, Oil & Gas Meeting, March 1999

The ACT Club recently hosted a meeting targeted at the Oil and Gas Industry (see report on Page 3) which focused on the performance and cost benefits improvements that have been achieved through the use of advanced control.

This future event is intended to expand on the interest generated by the previous event and will coincide with the commencement of our *Energy Special Interest Group*. We hope to follow the same structure as the previous event and include a number of company presentations.

This meeting will be held in Aberdeen to attract a strong participation from the North Sea Oil and Gas Industry and is scheduled for March 1999.

PID Control Day, 20th May 1999

This meeting will report on recent advances with the commonest form of controller, the PID, including new auto-tuning techniques. It will be hosted by Prof.. Derek Atherton at the University of Sussex.

Improving Control in Cold Rolling Mills

The success of the Hot Rolling Mill course (see Page 3) has encouraged us to develop a Cold Mill course for 1999. The course will again be aimed at plant engineers concerned with the operation and maintenance of Cold Mills. The course will therefore be at quite an introductory level.

It is hoped that the same type of international representation will be present at this course as was present at the previous event. A number of companies have already expressed an interest in promoting the course. The arrangements have yet to be finalised, but following feedback, it is likely to be a little shorter than the full-week of the previous event. Club members will again receive two free places, whilst non-members will pay a fee of £2,700 per delegate.

We hope to establish these courses as an annual event and that this will form the beginning of a *Metal Processing Special Interest Group*.

Further details of this course can be obtained from Reza Katebi in the ICC, (tel.: 0141 548 4297 or email: r.katebi@eee.strath.ac.uk).

Full details of all the above events will be circulated to Club members 6-8 weeks prior to events taking place

Steering Group Report

The *ACT Club Steering Group* met at BG Technology on the 26th October, featuring the usual discussions on defining future Club activities and priorities. Prof. Ron Leigh of Brunel University was present and he described the shape of the new London based Centre.

We are always willing to accept new members onto the Steering Group, and at the moment we are looking for nominations for the position of Chairman.

The *next* Steering Group meeting will take place on the evening of the 19th May, prior to the meeting on PID

Control. It is likely to be held in one of the nearby hotels and will hopefully combine both work and pleasure.

New ACT Club Predictive Control Toolbox

The long awaited ACT Club Predictive Control Toolbox for Matlab is now available in a pre-release evaluation form. This Toolbox is a very user-friendly means of trying predictive control algorithms without the need for a detailed understanding of the theory. The user interacts with the design entirely through Graphical User Interfaces and dialog boxes. The Toolbox includes the following features:

- A state-space system description is used allowing multivariable systems to be handled easily.
- The new algorithms, developed in the ICC, provide better stability and robustness properties, and are presented along with the more traditional algorithms
- Constraints on both plant input and output signals can be handled
- The designed controllers can be tested using both linear and non-linear models developed within SIMULINK.
- A demonstration example of a gas turbine model is provided.

The toolbox nature of this package enables the user to take the various elements within the toolbox and incorporate them into their own simulations in a very convenient manner. It is the most professional of the ACT Club packages to date.

This toolbox will be launched formally on the 14th April as mentioned previously in this newsletter. The pre-release version Toolbox is fully functional and is being made available to companies for comment and evaluation purposes. If any Club member would like to evaluate this software before

its formal release then please contact Andy Clegg at the usual address.

Recent ACT Club Events

Introduction to QFT

A very successful meeting on Quantitative Feedback Theory was hosted by CEGELEC at Rugby in response to requests from Club members for an introduction to this subject. In addition to the tutorial introduction, a range of applications was considered and the benefits and advantages of QFT outlined.

QFT extends classical frequency domain design approaches to provide truly robust solutions. It is applicable to many systems, ranging from process control to aerospace. The meeting attracted over twenty delegates and an introductory report was issued. This report has now been issued as an Educational Note.

Applications of Knowledge Based Systems

This one-day meeting held at BG Technology, Loughborough brought together speakers from many industrial sectors. Their common interest was in the application of Knowledge Based Systems and they described their own particular experiences: Applications included:-

- Hydro-Electric generation
- Gas distribution and forecasting
- Electric-arc furnace scheduling
- Gas-turbine monitoring
- Process plant diagnostics
- Intelligent product manuals

The meeting was very interesting and also included a tour around BG Technology's site and areas of work.

ETSU supported Oil and Gas Day

This was a very successful event supported by the Energy Technology Support Unit (ETSU), which looked at Advanced Control for the Oil and Gas Industry. The aim was to promote the benefits that Advanced Control can provide through presentations discussing real-life experiences.

The meeting was attended by thirty participants from many International Oil and Gas companies as well as ACT Club members.

Joint ACT Club/ICC Hot Rolling Mill Control and Technology Course

The above event, held 14th-18th September at Strathclyde University, attracted both Club members and paying non-Club members from many different countries, making this a truly international event. The lectures and practical sessions were well received and overall the course proved very worthwhile for delegates and lecturers alike. The course banquet was held at the Charles Rennie Mackintosh designed "House for an Art Lover" and proved a fitting end for our first such course.

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

New ACT Club Members

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

Kodak became the first company to join through the new London Centre (see article on Page 5). Kodak are primarily concerned with process control for their film production, and as such are heavily involved in Chemical engineering and batch processes.

Cerestar (food stuffs producer) and **Omron** (PLC manufacturer) are both looking to follow in Kodak's footsteps and join through the London Centre early next year.

Hot Rolling Mill Course Delegates at the Mackintosh inspired House for an Art Lover

New ACT Club Reports

"Introduction to QFT"

The recent ACT Club event on Quantitative Feedback Theory demonstrated the interest that Club members have in this subject. This Educational Note is a basic introduction to QFT and describes the design process and underlying theory in a very easy to digest form.

The bulk of the report presents a tutorial example for a Single-Input Single-Output control system. It shows how plant uncertainty is represented and is incorporated into the QFT design. It then goes on to look at stability, disturbance and tracking bounds that ensure that closed loop stability and tracking performance requirements are met.

The report shows that QFT is a very practical method for controller design and that for many industrial applications it can yield significant benefits over classical control design methods.

"Supply Chain Dynamics" Case Study

This Case Study was undertaken for Unilever Research and was commissioned to establish the state of knowledge of applying control systems theory to supply chains. The term *supply chain* refers to the links and feedback interactions between production, distribution and retailing centres associated with the supply of manufactured goods.

The report looks at the different methods of modelling these supply chains and also how these can be enhanced so that control theory can be applied to what is essentially a feedback system.

The report makes very interesting reading for anybody and should be of particular value to anyone involved in manufacturing and distribution problems.

"Fibre Optics and their use in Field Trials Measurements Systems"

This Technical Report was the outcome of a short study undertaken for Lloyd's Register of Shipping to examine the potential use of fibre optic cables within their field trials measurement systems. The report looks at the major characteristics of fibre optics cabling and it's applicability for temporary field installations.

The report looks at the different types of fibre optic cables available, how they are tested and the various components that constitute a fibre optic data communications network. A comparison with conventional copper cabling pertaining to Lloyd's particular application is also included.

The report should be of interest to anyone considering using fibre optics for data communications whether in a permanent or temporary installation.

"Introduction to Mathematica"

This Educational Note introduces the world of symbolic manipulation as it describes the new Control System Professional toolbox that accompanies Mathematica, the symbolic computation package. The Control System Professional allows control system designs to be carried out utilising the power of symbolic equations.

The report is presented as a brief tutorial into the use of Mathematica and it's wide range of capabilities. It then goes onto describe the various functions that are available under the

CSP and demonstrates the benefits of symbolic manipulation.

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 the Club Case Study Reports, Technical Reports and Educational Notes can be found on the last two pages of this newsletter.

ACT Club WWW Site

The ACT Club WWW Site is now attracting many people. We hope to increase the usefulness of this resource very soon by introducing an extensive library of resources both within the Club and on the Internet. This should establish the ACT Club WWW Site as a key resource for any engineers wanting to find out more about either particular control techniques or specific applications.

We are also in the process of making the Club reports and software available over the Internet so that Club members can download these items as and when needed.

The development of our WWW Site is a continuous process and major improvements will occur during next year. Any comments and ideas about how we can improve the WWW Site will be gratefully received.

Remember, our WWW site is at:

http://isc.eee.strath.ac.uk/ actclub.html

New ACT Club London Based Centre

Recently the benefits of the ACT Club were extended both technically and geographically with the establishment of the London centre.

London Centre for Technology Transfer off to a Flying Start

- The newly launched London Centre provides specialist expertise in Process Control, Monitoring and Control of Biotechnological Processes, Electrical Power Systems and Networks and Control of Food Processing Plants.
- Members of the London Centre simultaneously obtain access to all of the facilities and events of the ACT Club.

Technology Transfer consists of supplying:

Awareness of latest technologies, particularly in the areas of: Data Analysis, Applied Computation, System Modelling, Simulation and Control, Process Diagnostics, Robotics, Knowledge Handling and Systems Implementation.

Expert and Informed Assistance to help industrialists choose the most appropriate technology for specific applications.

Practical Assistance translating the chosen technologies to efficient plant implementations.

Another Geographical contact point to augment the ones already established by the ACT Club.

The London centre provides:

- A programme, chosen by the Centre's Industrial Members, including:
  - Customised training workshops
  - On-plant visits and assistance
  - Case Studies
  - Opportunities for interaction and meeting other industrialists.
  - Link to all ACT Club facilities and events
- A priority position from which to participate in and benefit from collaborative research projects that complement the Technology Transfer activities.

The London Centre already has Members from the Process, Food and Systems Supplier Industries and the programme of events will commence in early 1999.

Activities already scheduled for the London Centre include:

- Assistance with a *Process Validation* project in which large volumes of data are interpreted on-line, possibly using parallel processing techniques.
- Assistance with a project *Robots On The Food Production Line.*
- Provision of short courses on Power *Distribution Networks And The Effects Of Harmonics.*
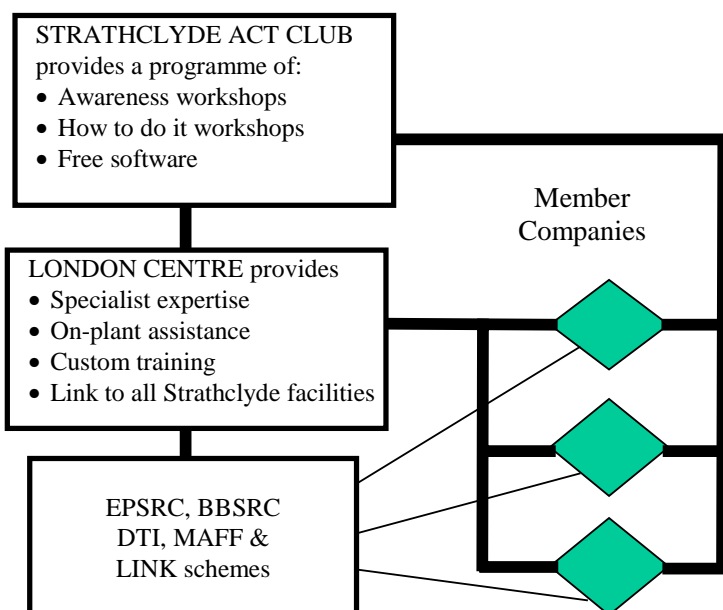
We are moving swiftly to take on further Members, so if your Company wishes to participate please make your interests known to us as soon as possible.

London Centre for Technology Transfer: Enabling and Underpinning Research

- Useful information from large data sets
- Systems Integration (EPSRC initiative)
- Research to underpin CIM, SAP, ERM etc [large scale factory automation]
- Underpinning of use of AI tools
- Where's the flair-Forum for new ideas

In the first instance please contact:

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STRATHCLYDE ACT CLUB provides a programme of:
- Awareness workshops
- How to do it workshops
- Free software

LONDON CENTRE provides
- Specialist expertise
- On-plant assistance
- Custom training
- Link to all Strathclyde facilities

EPSRC, BBSRC DTI, MAFF & LINK schemes

Member Companies

CONFERENCE NEWS

Liberty, Fraternity and the American Control Conference.

The **1998 American Control Conference** was held in Philadelphia, Pennsylvania home of the famous Liberty Bell.

The high point of this year's ACC was the presentation by Prof. Rudolf Kalman on Mathematical Systems Theory in the 21st Century. His talk was mostly philosophical in nature with quotes from Cicero to Mark Twain. The quote from Cicero seemed particularly appropriate "those who don't know the past, cannot imagine the future". Kalman pointed to the importance of basic scientific research and distinguished between this and the other possible research routes such as goal oriented, commercial and popular research.

A number of awards were made at the meeting and the most prestigious was that to Lotfi Zadeh who was presented with the Bellman Control Heritage Award. Prof. Zadeh is very well known for his contribution to fuzzy set theory. He was able to amuse the audience with his reminiscences regarding previous comments made on the value of his approach. One of his transparencies included a quote from Prof. Kalman in 1972, which went "His proposals could be severely, ferociously even brutally criticised from a technical point of view. This would be out of place here. But a blunt question remains Is Prof. Zadeh presenting important ideas or is he indulging in wishful thinking". He also quoted from an NSF Grant Application in 1989 where the reviewers recommended: delete all material on fuzzy sets; it has been proved to lack a sound mathematical basis. Prof. Zadeh noted that from a quick survey of the number of papers with fuzzy in the title in Mathematical Journals

over the last three years 3,240 were found. Prof. Zadeh enjoyed being able to say I told you so.

Amongst the other outstanding awards was that to Prof. Ioannis Kanellakopoulos who received the Eckman Award and Prof. Peter Dorato who obtained the Ragazzini Education Award. Both Prof. Kanellakopoulos and Prof. Dorato are very well known for their work in their respective fields of adaptive and robust control, and their contributions have been significant. It was particularly pleasing to see Charles Cutler recognised through the Control Engineering Practice Award. His contributions to the development of dynamic matrix control were fundamental and has found extensive application in the petrochemical industry. He developed one of the outstanding products (DMC) that has introduced advanced control into a range of industries, demonstrating the real cost savings that can be achieved.

The main industrial Plenary of the week was by Dr. Ogunnaike of DuPont who discussed the control of chemical processes. His objectives for a successful control system were:

1. The process should operate safely.
2. The specified production rate must be achieved.
3. Desired product quality must be maintained.

He noted that the chemical process industry worldwide is worth about 1 trillion dollars. However, there are relatively slim profit margins on huge volumes. One of the distinguishing characteristics seems to be the very long-term capital investment programmes required and the fact that each plants is unique. He pointed to the need for more efficient utilisation of these very expensive assets and the role that improved control systems can play. He showed that it is possible to improve product

quality and yield, whilst at the same time reducing product variability. He also stated that competitive benefits were often only achieved by squeezing the performance of the control system to get closer to operating limits.

Dr. Herbert Hanselmann, who is President of dSPACE, considered the relatively hot topic of real-time control. dSPACE is the hardware that enables MATLAB to be used right from the design stage through to implementation with real plant. He stated that code-generation tools can remove the bottlenecks and optimise the whole development process. His examples were taken from the automotive industry where there are severe pressures on emission standards and fuel consumption, and additional control loops are now required for many additional automotive functions.

One of the most interesting sessions concerned control education over the World Wide Web. Christian Schmid (Ruhr University) described a virtual control laboratory and Molly Shor (Oregon State University) described a Netscape control laboratory facility, which enabled remote access to a robot arm. This enabled students to remotely conduct experiments in the laboratory. The robot arm is housed in a secure and safe environment and the student who logs in first gains access to the experiment. There is real-time video display so that the behaviour of the robot in the laboratory can be observed and time-domain plots can be obtained.

One of the new topics to emerge at the Conference is the subject of non-fragile controllers. There can be pit-falls when implementing advanced controllers, which may appear to have better properties, but when implemented in a real DCS system may give rise to unpredictable performance.

There was a lot of interest in the subject of fault detection. Jason Speyer (University of California) gave a particularly interesting presentation of game theory for decentralised fault detection filtering. Jakob Stoustrup (Aalborg University) described the related approach of multi-objective design techniques for fault detection and isolation. Mike Rank (Technical University of Denmark) considered the problem of threshold selection for fault detectors.

The Sessions on model predictive control were very well attended and James Primbs (CALTEC) discussed the use of nonlinear control with a receding horizon and Lyapunov control functions. Although the results were a little academic they did tackle a very difficult problem where results are needed. Basil Kouvaritakis (Oxford University) described a computationally efficient constrained predictive control law to handle rate constraints.

A number of sessions were concerned with metal processing and Harutoshi Ogai (Nippon Steel) considered the use of fuzzy set theory for dynamic set-up of hot strip mills, roll pressure modelling in cold strip mills and edge drop set-up systems in cold mills. Their experience with fuzzy set theory is encouraging since it has led to so many applications. Anke Xue (Zhejiang University) described a real time expert system, which was integrated with a GPC control law for cold strip mill control. It seems the expert system is used to optimise set points of the predictive control loops. Juan Fei Qiao (Northeastern University) described a new method of flatness control in cold rolling. The method he proposed involved fuzzy recognition with a more conventional self-tuning controller. It was interesting that in all of these examples of real applications there was a need to combine some form of intelligent control with more conventional model based or adaptive control methods.

Greg Stewart (Honeywell-Measurex Deveron Inc) presented an impressive paper on the use of robust generalised minimum variance control for paper machines. A paper by Brian White (Cranfield University) on Robust Flight Control considered the use of Eigenstructure Assignment type methods. He was able to provide convincing evidence that low interaction between channels could be achieved and robustness improved. Lin Chujen (Intelligent Automation, Inc) considered the use of neural networks in submarine pitch and depth control. One of the main benefits of his solution was the ability to accommodate the nonlinear variations in submarine dynamics.

It may only be a temporary change but this year's ACC seemed to be emphasising industrial applications much more strongly. The standard of the applications papers certainly seems to be improving, although a little of the excitement that comes with some rapid theoretical advances, may have been missing. Nevertheless this was a valuable event which had the virtuous outcome of bringing academics and practitioners an improved mutual understanding.
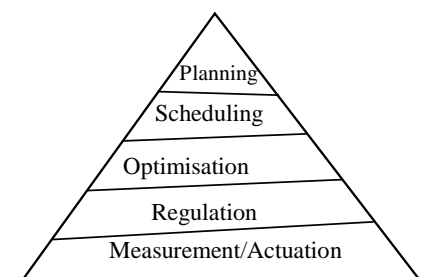
Italian Style and Control Engineering

The **1998 IEEE Conference on Control Applications** was held in Trieste, Italy, 1-4 September 1998. It was held in the Stazione Marittima, which is on the sea front. In fact this is the first conference I have attended where warships moored at one side and ferries the other side of the event.

A number of plenary papers were presented of which the presentation by Manfred Morari (ETH, Zurich) on the control of systems with continuous dynamics, logic and constraints was particularly impressive. Morari's talk centred on model predictive control, which has been spectacularly successful in the petrochemical and chemicals industries. His contention was that this was the only technique which was really suitable for integrating together logic systems, continuous dynamics and system constraints. He described AspenTech's success which has grown in fifteen years to a turnover of $180 million has been mainly due to the use of this approach. They have apparently 1400 application of true multivariable control but he noted only 10% of these needed some type of non-linear control (usually a simple non-linear transformation) and less than 5% required multiple models or gain scheduling.

Morari asked why predictive control is so popular and widely used. He concluded that for tough systems involving multivariable dynamics and multiple constraints, there was no real alternative approach. One of the technological developments he pointed to was the convergence in performance of DCS systems and PLCs. It was his belief that by the year 2000 these systems would be very similar and provide new opportunities for control.

Morari stated that the above diagram, which is shown in many process control books, would not be applicable in the future since advances in computer science are blurring these boundaries. Even with today's systems real-time optimisation with model predictive control gives rise to fluent boundaries. Tomorrow he believed there would be smart manufacturing through the integration of plant control and business systems. He

quoted British Petroleum whose interest is in the integration of their operation from oil well to the petrol station. New paradigms will be needed for integrating these layers.

His theoretical conclusion was that more general system descriptions are needed to mix together these logical and continuous time dynamic problems. He gave numerous industrial examples of illustrating the mixture of requirements. For example, the gas supply system for Kawasaki Steel uses very complex rules for boiler operation, regarding the time it should be switched on, the sequencing involved and what should happen if the type of fuel should change. Future integrated systems must be able to deal with this type of mixed sequencing and continuous control problem. His other examples included hydroelectric power plant, automotive active levelling systems and fault detection systems for steel rolling mills. He described one possible way forward combining logic and artificial intelligence, and utilising linear programming type techniques. His quadratic objective functions combined continuous and integer variables. He noted that the branch and bound strategies for solving mixed integer quadratic problems are very effective. In fact the Kawasaki Steel plant, gas supply problem involved a control computation time of just 1.2 seconds on a Sun SPARC 4 computer.

Jean-Jacques Slotine (MIT) described a practical approach to non-linear control applications in his plenary presentation. The approach he introduced was contraction analysis, which he explained could be considered a generalisation of linear eigenvalue analysis. The approach seemed particularly relevant to his own area of robotic control but there were also aerospace, underwater and process control applications which could utilise such results.

The third plenary presentation was given by Jim McWha (Boeing) who described the development of the 777 aeroplane, which is a very

technologically advanced aeroplane where the control engineering problems are challenging.

Tariq Samad (Honeywell Technology Centre) organised a session entitled "what is new and exciting in control". Not surprisingly this attracted considerable interest and he presented the first talk called "Control in an age of complexity". In some respects his talk supported the plenary presentation by Morari since it drew attention to the wider systems problems control engineers must now consider. Frank Lewis (University of Texas) gave a particularly stimulating presentation on new developments in neuro-control. There is continuing development in the area of neural networks with researchers still proposing their use within the control loop.

Nunzio Bonavita (Elsag-Bailey) described improvements in process control through the use of model based techniques from a control systems vendor's perspective. He drew attention to the fact that control system suppliers deal with a much larger range of problems than simply control algorithms. He also reminded us of the obvious but important lesson that any new control technique that is developed, must be transparent and easy to use and apply.

Haniph Latchman (University of Florida) described recent work on a perturbation radius used in the robust design of H∞ controllers. To some extent this measure is a generalisation of the idea of gain and phase margin. However, it takes into account the form of the uncertainty and in particular, the vector direction of the uncertainty, relative to the critical point for stability. The criterion he defined enabled systems to be designed with H∞ weightings that would not be so conservative.

Masanori Yukitomo (Toshiba) described a new PID controller tuning approach with application to Flue gas temperature control in gas

turbine power plant. His approach was to calculate a linear quadratic optimal controller and then calculate the open loop frequency response. He then approximated this response using an open loop characteristic based on a PID controller. The PID coefficients were then chosen to minimise the error between these two frequency characteristics. Such an approximation of the open-loop frequency response does not guarantee stability but it did provide a simple and easy to use method of computing the PID controller coefficients.

Conference Proceedings on CD-ROM

Both the above Conferences have their proceedings on CD-ROM, copies of which are held within the Industrial Control Centre. This provides a convenient means of storing and retrieving the many papers as well as providing a powerful search facility.

The programme for these events can be obtained from Lorna Fleming from which you can then determine any papers that may be of interest.

Energy Special Interest Group

The actions towards establishing the Energy SIG have been progressing in the ACT Club for some time and have included:

- Tutorial Session "Improving the Quality of Control in the Power Industry 25th August 1998, Glasgow
- Meeting on "Process Control for Profit and Energy Efficiency for the Oil and Gas, Power and Utilities", 14th October 1998, Glasgow, supported by ETSU.
- MSc Project highlighting the problems and procedures for multivariable control in the process industry. This work is continuing as a PhD project and may result in an Energy SIG Case Study
- Meetings and discussions with companies such as Marathon Oil, British Energy, Scottish Hydro and National Grid.

It is our intention that the Energy SIG is formally established during the Energy, Oil and Gas meeting being held in March next year.

The possible topics of interest of this SIG may include:

- Multivariable control for optimisation of energy and material consumption.
- Dynamic simulation of energy systems for improved on-line assessment of performance.
- Hardware and implementation issues for control in the energy, oil and gas industries.
- Benchmarking control practice in the energy, oil and gas industries.
- Safety critical design and reliable control.

Of course, the specific actions to be undertaken will be decided by the interested members at the kick-off meeting. Therefore the above list are merely suggestions.

Also, there are several on-going activities in the Industrial Control Centre that may be of interest to the Energy SIG and may help in defining the SIG's programme. These are:

- THERMIE – implementation of advanced voltage regulation. Partners: ENEL, ABB and Red Electrica.
- IN-CONTROL – benchmarking advanced control algorithms. More details in the next article.
- Process Control Room Simulator – submitted to JREI. Partners: Elsag-Bailey, Scottish Power, COGSYS, Feedback Instruments, ACT Club.
- Multiphase Flow Modelling for Improved Control Performance of Oil Platform – under discussion.
- PhD Project on Advanced Multivariable Predictive Process Control – just started.
- Joint project with Oxford University on Predictive Control – under discussion.

We believe that the forthcoming meeting in Aberdeen and the formation of the Energy SIG will generate a substantial interest among the Club members. Of course we will keep you informed on the development of this initiative. In the meantime, we will be canvassing the opinion of the Club members by sending a letter and a questionnaire to companies who potentially may be interested. Also, any form of feedback on the above from any Club member would be very much welcomed.

European Union Supported Benchmarking Project

How well are your control systems performing relative to your most effective competitors? This question is the subject of a new project within the ICC, which is concerned with benchmarking. The aim of the project is to develop procedures and tools that will enable effective comparisons to be made with current best practice.

It is difficult to even compare two similar plants owned by different companies. However, there are methods of establishing whether the control systems are well tuned. Mike Johnson in the Industrial Control Centre is investigating one such method that uses contour maps to determine how well PID systems are tuned. This is an old idea brought up-to-date through the use of new technology and techniques.

This benchmarking project is supported by the EU and involves Elsag Bailey (Italy), Red Electrica (Spain), Deutsche Babcock and the Universities of Aalborg (Denmark), Genoa (Italy), Bocam (Germany) and Strathclyde University. The project manager is Dr Andrzej Ordys and he is able to invite contributions at the various meetings. If you would like to contribute to such an event, which would usually be a two-day meeting, then please contact either Andrzej or Mike Grimble.

Professorial Appointment for Mike Johnson

I am sure all Club members will be very pleased to hear that the University of Strathclyde has appointed Mike Johnson as a Professor of the University with a title of Professor of Industrial Control.

ACT Club Control Engineering 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 (One 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 (One 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 (Two Day)

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 <u>most popular</u> 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 (Two Day)

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$_x$ (Three Day)

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 (Six Day)

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 (One Day)

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

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

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

Course 9: Robust Controller Design (Two Day)

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 and Deliverables to Members

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*)

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

SCOTTISH NUCLEAR: Control Room Alarm Analysis Toolkit (*On Going*)

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 Methodology 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 *(TR17/1998)*

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 MATRIX$_X$

Multivariable State-Space Predictive Control Toolbox for Matlab

If you require more copies of **The ACT Club News**, then please complete the form below and return by to Lorna Fleming at 50 George Street, Glasgow, G1 1QE. *tel.*: (+44) 0141 553 1111, *fax*: (+44) 0141 553 1232, *email*: lorna@isc.eee.strath.ac.uk.

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