Activity Report: Automatic Control 1982-1984

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ACTIVITY REPORT
1982–1984

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Abstract

The report surveys the activities at the Department of Automatic Control, Lund Institute of Technology, during the academic years 1982–83 and 1983–84. At the civilingenjör level (≈ MS) seven different courses are given on regular basis. About 700 students have participated during the year. Also 29 MS-theses and 3 PhD-theses have been completed.

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Contents

1. INTRODUCTION

This report covers the activities of the department in the academic years 1982/83 and 1983/84.

As regards instruction, substantial efforts have been made to renew the courses and teaching laboratories. The curriculum has been extended significantly including the addition of several control courses adapted to the computer science curriculum, and a new course in process control for the chemical engineering students. The teaching laboratory for the basic courses has been completely renewed. The courses on computers in control systems have been significantly changed. Further description is given in Section 2.

Research has continued in established areas such as adaptive control and computer aided design. New areas like image processing and computer aided engineering have been established. Several full scale application projects have also been carried out in wind power, nuclear reactor surveillance, wastewater treatment and biotechnological processes. These projects are described in Section 3.

There are several interesting fields being considered for continuing research. The area of adaptive control is one of them, with promising prospects. Much effort will be devoted to expert control and artificial intelligence. Computer aided engineering will be an ongoing project for the next few years. On the other hand the projects on wind power and nuclear reactor surveillance will be completed in the near future.

In Section 4 a brief survey of the laboratory software and hardware is given. Our interactive software has been extremely successful. In cooperation with STU (the Swedish Board for Technical Development) the software has been sold all over the world to both industries and universities.

We want to thank our sponsors, The Swedish Board for Technical Development (STU), The Swedish Institute of Applied Mathematics (ITM), The Swedish Council for Planning and Coordination of Research (FRN), the Swedish Board for Energy Source Development (NE), The Swedish Water and Wastewater Works Association

(VAV), The Käppala Sewage Works, Lidingö, and Sydkraft AB for their support to our projects.

Certain reports and theses are available for sale from the Department, see further Appendix C.

2. Education

Automatic control courses are tought as a part of most engineering curricula. To integrate automatic control courses into widely differing engineering curricula means a large teaching and course development demand on the department. At the same time this affords the advantage of teaching basic control with similar terminology and approach for different groups of students. During the past years the following number of students have passed the courses:

	82-83	83-84
Automatic control, linear systems (F,E,D)	115	137
Automatic control, linear systems (M,(K))	55(3)	66
Automatic control for chemical engineers (K)	22	29
Principles of automatic control (K)	5	3
Computer controlled systems (F,E(K))	28	38(2)
Systems engineering (M)	9	9
Computers in control systems (F,E,M,K)	34	22
Applied real-time programming (F,E)	57	62

Twenty-nine students have completed their MS-dissertations in Automatic Control during the period. A list of the MS-theses is given in Appendix C. Three PhD-theses have been completed during the period. A list of the PhD courses given is found in Appendix D.

New or Revised Courses

The demands on more automatic control courses have increased considerably during this period. For this reason the basic course on Linear Systems has been split up into two, one which suits the needs for applied physicists (F) and electrical engineers (E) and a slightly different one for mechanical engineers (M). The latter course will be changed gradually to better suit the special needs of mechanical engineers. Also the number of laboratory hours has increased.

Beginning in the fall of 1984 all chemical engineers (K) have a compulsory course in Process Control. This will replace the two courses "Automatic Control for Chemical Engineers" and "Principles of Automatic Control". It will have the same amount of lecture and laboratory hours as the other courses on linear systems.

A new curriculum for engineering students in computer science (D) started in 1982. The first course for computer science students starts in the fall of 1984.

The course on Computer Controlled Systems has been reworked which is confirmed by the newly published book by Åström-Wittenmark, "Computer-Controlled Systems", Prentice Hall, 1984.

Teaching Laboratory

The teaching laboratory is known to be an extremely important part of the control education. Simulation experiments are not sufficient to give the student a good understanding of the basic principles of control. A major effort has been made to upgrade the teaching laboratory during the past two years. All four laboratory exercises in the Linear Systems course have been revised, and analog techniques have been replaced by digital technology. New equipment has been acquired and the laboratories are now centered around a tank process newly built at the department. The control is implemented on Apple IIe computers. In four laboratory exercises the control is gradually made more complex. In the first experiments empirical tuning of a PID controller is made. Later mathematical models are derived and tested. Digital realizations of PID-controllers, with anti-reset windup, bumpless transfer and filtering are studied. Regulator design and tuning is now based on models. State estimation and feedback is implemented. New software has been developed to meet the challenge of presenting this material effectively in the given time period.

The course Computer Controlled Systems has been completely revised during the last couple of years. It is now based on the book "Computer-Controlled Systems" by Åström and Wittenmark. The laboratory exercises and the problem solving sessions have been adopted to the new course. For instance the interactive simulation package Simnon is used both in the problem solving sessions and in the laboratory.

In order to meet the increasing interest in robotics, projects were defined in robot control in the course of Systems Engineering. Robotics (including servo techniques) will also play an increasing role in the mechanical engineering courses.

The course on Computers in Control Systems has been renewed during the Spring of 1984 with new lecture notes and two new laboratory exercises. The course is intended to educate the potential user, rather than developer, of real time systems.

In the course on Applied Real-Time Programming advanced project work has made up the larger part of the course. A mechanical balancing ball-and-beam system is used as the process. Students are required to program and implement a laboratory computer control system. One group designs operator communication on one computer. Last semester an IBM PC was used and a window manager was implemented in Modula 2. Another group performs the sequencing and feedback control on another computer. It is implemented on LSI 11 computers in Pascal supplied with a real time kernel. A third group designs the computer communication software.

Extension Courses

There is an increasing demand from industry on courses in the control area. To meet this interest the ambition has been to give at least two courses per term on various topics for engineers from the industry. The courses have given a lot of stimulation for the research and education at the department. A list of the courses given is shown in Appendix D.

3. Research

Research at the department is oriented along two main paths, theory and application. Methodology and new theory is being developed often with no particular application in mind. New theory lays the ground work for the other aspects of research, particular application problems. Applications research is the professional use of available methods to solve the particular problems that appear. During the years there has been a fruitful interaction between the methodology and the application groups.

Research results for the department are collected below under separate project headings. At each headline the main investigator is named first. Often other persons are involved. The senior staff is naturally involved in many areas concurrently. Masters students also often make good contributions to the results.

Adaptive Control

(Karl Johan Åström, Tore Hägglund, Rolf Johansson, Björn Wittenmark)

Adaptive control has been a vital part of the research efforts at the department since the end of the sixties. A special STU project on adaptive control has been in progress since 1978. Both theoretical development and practical applications have taken place. The results have been extremely successful, not simply in terms of publications and conference contributions. Several groups of researchers at universities and industries have started new areas of research work, inspired by the results from Lund. Commercial products have also been developed, e.g. the ASEA Novatune and the NAF Autotuner.

Adaptive Controllers for Multivariable Systems

The goal has been to derive algorithms for multivariable systems in the sense that parameter identification and control law calculations can be done with a reasonable computational effort.

The approach to parameter identification was made with established estimation methods, that assume systems linear in the parameters. The parameterization is such that the control law could be calculated from addition and multiplication of the matrices involved. With these features the computation could be less cumbersome.

For control synthesis the multivariable case is much more elaborate than the single-input single-output (SISO) case. Pole placement methods are not so simply related to different optimization criteria as is true in the SISO case. Still the results can be interpreted in terms of response times etc., and the methods are mathematically attractive.

The decoupling problem has also been studied and been incorporated into the multivariable pole placement algorithms. Both static and dynamic cross couplings have been considered. The results have been documented in the PhD thesis by Rolf Johansson.

Stability

Stability for adaptive controllers has been studied. By using Lyapunov theory for the stability analysis it has been possible to study the stability properties for a class of time discrete adaptive systems. For this class of systems exponential convergence of the control error can be shown.

Adaptive Control of Time Varying Systems

Adaptive controllers can be used favourably in systems with time varying dynamics. The main problem in such systems is, that old information may be irrelevant due to the changing dynamics. Thus recent data has to be given more weight. Heuristic methods to increase the estimated variances are common. This may cause problems during periods of little information.

A new method to accumulate information has been derived. In principle the information is controlled in the sense that new data is weighted so that the parameter variances are constant. This new approach has solved several old problems with the heuristic methods.

A special case of time variability in systems with large and relatively fast changes can be detected with so called fault detection methods. Consequently the adaptive controller can react quickly to the changes. Existing fault detection methods are usually not suitable here. A common assumption is a constant noise level, which is not realistic in adaptive systems. The research in this field is documented in the PhD thesis by Tore Hägglund.

Automatic Tuning of PID Controllers

A new method to find the parameters of a conventional PID controller has been developed. It is based on a completely new identification idea, and has been patented. The patent has been transferred to NAF Controls, and a commercial product, the NAF Autotuner was announced in March 1984. It has been tested in industrial environment with great success. The autotuning idea has a lot of potential, both practically and theoretically. One of the interesting theoretical problems is what happens during relay control of processes.

Robust Controllers

A PhD thesis by C. Rohrs at MIT has inspired work on robust properties in adaptive controllers. If a simplified model is adjusted the result of the control depends significantly on the input signal properties. The input has to be sufficiently complex to allow the adjustment of all the parameters in the model. If the input signal is too simple the parameters cannot be adjusted.

Suboptimal Dual Control

Dual control problems still lead to cumbersome computations. Therefore it is interesting to seek simplifications without sacrificing too much control quality. In this case a cautious (suboptimal dual) controller is created by adding an extra term to the loss function. This term reflects the inaccuracy of the process parameter estimates. A simplification of the calculations can be achieved by a series expansion of the loss function. The series is truncated suitably. Simulations have shown that the new control algorithm gives a better control in comparison with other suboptimal controllers. It is easy to implement and can be further generalized to more complex systems.

Adaptive Control of Delay-Differential Systems

Processes with time delays (e.g. caused by recirculation flows) are generally difficult to control. An approach to adaptive control of systems with time delays and recirculations has been made. Hitherto the results are promising.

Adaptive Start-Up Control

Start-up control problems arise when a process has to be controlled from one operating point to another. The process properties are to some extent unknown, but the controller can be chosen from a set of possible models. The method to make this choice is investigated in adaptive start-up control. The main idea is to reject impossible models as soon as possible. The input is chosen according to the worst case and is gradually refined. Start-up control has been applied to heat processes and an implementation on a laboratory scale heater is performed. The work has been presented in a PhD thesis by Matz Lenells.

Education

An overview of adaptive control is now presented in the course on Computer Controlled Systems. Moreover, industrial courses on adaptive control have been given, see Appendix D.

Language Implementation in Control Systems (LICS)

(Hilding Elmqvist)

This project has been carried out in connection with the Centre for Industrial Computer Systems (Centrum för Industriella Datorsystem - CID). CID has been a joint effort between the departments of Automatic Control and Computer Engineering supported by the Swedish Board for Technical Development STU. The goal for LICS has been to develop a system for documentation, implementation and testing of computerized control systems. The project will be completed in the Fall of 1984.

The first part of the project has mostly been concerned with the programming environment for the developer of control systems. A goal has been to make it possible to use graphical input for structured information and text input for algorithms.

A graphical system has been designed and implemented which allows representation of hierarchically decomposed interconnected modules. Each level in the hierarchy is represented as a block diagram. The viewer has joysticks which move a window over the picture and to zoom the picture. This is done in real time (animation). When a block is zoomed-in, the next level of the hierarchy is faded-in (information zooming). The lowest level of the hierarchy uses text descriptions for algorithms and documentation etc.

When a description of a control system has been created using the graphical and text editors, the user can demand a compilation of it. The interpretation of the picture involves handling of module hierarchy, interface hierarchy and connections. The text descriptions are compiled using standard techniques. An abstract syntax tree is built up as an internal representation of the control program.

The prototype graphic system that has been implemented has taught us and many visitors that the concept of information zooming gives a new dimension to man-machine interaction. It also gives a new solution to the problem of handling documentation of large systems in a structured way.

The algorithmic part of the language has also been designed. It is specially designed for description of dynamical systems and signal flows and allows an extensive fault checking. A semantic model has been implemented as an interpreter for the abstract syntax tree. Further documentation of the project is currently in progress.

Control Based on Picture Information - Visual Servoing

(Lars Nielsen)

The goal for this project is to study pictures and sequences of pictures in control applications. A typical application is industrial robots, where manipulation is based on the visual information of surrounding objects. Even movable robots can be considered within the same framework of visual servoing.

A modern measurement technology has been adopted to represent the picture in the computer. The information from a video camera is transferred to an image memory interfaced to the VAX 11/780 system. The VAX system then has been used for the visual feedback control of some laboratory vehicles. By using a general purpose computer like the VAX and supply it with an image system we have achieved an important goal. Different algorithmic approaches can be tested, even if the speed is slower than that of a special purpose system. The results so far implemented in a general purpose computer indicate clearly the potential of using new special purpose hardware to implement the visual servoing.

The goal of the picture processing part of the problem is to detect and interpret picture changes. Sophisticated edge detection is already commercially available. Given this knowledge and hardware we have proceeded to develop algorithms for picture changes as a result of different perspective of moving objects. Furthermore, biological vision systems have inspired investigation, both experimentally and conceptually, of other approaches than edge detection to first step image features. In this connection a proper understanding of the relation between image resolution and visual servoing has to be understood. Results on optimal digitization of pictures have been obtained.

An experimental laboratory system has been built up, where all relevant features of visual servoing have been tested and demonstrated. The object of the visual servoing system is a moving little "turtle". The turtle may simulate an AGV (automated guided vehicle). The program includes such aspects as image processing, image interpretation, perspective corrections, feedback control along the path, route planning, obstacle avoidance, robot cooperation, and collision handling with touch sensors. Furthermore, the software includes a man-robot interface based on menu driven interactive computer graphics combined with images of the robot working environment.

Control of Wastewater Treatment Systems

(Gustaf Olsson, Lars Rundqwist, Ulf Holmberg)

The project started in 1982 supported by STU. The first activities in this field were initiated at the department already in 1973.

Adaptive Control of Aerators in Activated Sludge Systems

In cooperation with the Käppala Sewage Works and ASEA AB, self-tuning control of the dissolved oxygen concentration and the air production system of the activated sludge process at Käppala has been performed to get further insight into process dynamics and performance. A Novatune controller was installed in May 1983. Since then, different control experiments and evaluations have taken place. Significant investments in new control and measurement equipment has been made at Käppala. Several practical problems concerned with the process itself and the control actuators have been tackled.

In cooperation with the Institute for Surface Chemistry (Ytkemiska Institutet) water quality tests have been made to evaluate the influence of control on effluent water quality. Several interesting results have been found that show that an aerator with dissolved oxygen control will get a significantly different water quality than a reactor without control. However, this quality change is not always favourable in the controlled case. The reason is that the best reference value of the oxygen level for the microorganisms is not known. It is probable that the organisms need some periodic change of environmental conditions. The research continues on how to find such conditions.

Dynamical Behaviour of Clarifiers

Traditionally sedimentation and clarifying tanks have been described statically. In this project dynamical models have been established from full scale and pilot scale experiments. The research has been conducted in cooperation with Environment Canada. By using recursive identification to track essential clarifier parameters an early warning system can be established.

Hydraulic Properties of Treatment Plants

It has previously been assumed that hydraulic shock waves propagate instantaneously through a treatment plant. This is not true, and the time lag has to be taken into consideration sometimes. If control actions are based on flow measurements flow meter location becomes relevant. Hydraulic models have been derived and verified to full scale plants. Using these models the flow rate at a specific point in the plant can be reconstructed from measurements either downstream or upstream.

The consequences for plant design and pumping have been considered. The coupling between hydraulic propagation and clarifier dynamics has commanded a great interest among both researchers and operating people.

Dynamical Models for Biological Wastewater Treatment

A library of dynamical models of activated sludge systems is being built up. The models are formulated as Simnon systems and make up a spectrum of complexities in kinetics, hydraulics and combinations of subprocesses. In cooperation with the Swedish Water and Wastewater Works Association (VAV) a large amount of experimental data from wastewater treatment plants has been collected. A database for experimental data - from both on-line sensors and manual samples - is being established.

Several biological reactor parameters are difficult to measure but can be estimated. A method has been developed to recursively and simultaneously estimate biological respiration and oxygen transfer rate in aerators.

Control of Biotechnological Processes

(Per Hagander, Jan Peter Axelsson)

A cooperative effort on control in biotechnological processes has been established with the Department of Pure and Applied Biochemistry. The purpose has been to develop more elaborate control methods for biotechnological processes. At the Department of Biochemistry sensors based on immobilized enzymes and calorimeters have been successfully developed, and the potential of using them in

control systems have been explored. In the sensors a broad spectrum of enzymes or complete cells have been used together with signal transmission.

A fermentor with a volume of 8 liters and supplied with control equipment has been installed. It has been interfaced to a LSI 11/03 system. The practical experiments have been concentrated to ethanol fermentation in tube and tank reactors. The feedback control has been complemented with supervision of sucrose using a simple flow rate calorimeter. A membrane gas sensor has been used for the feedback loop.

Simulations of models have shown that conventional PID control is not sufficient for the processes studied. Different methods to take the cell growth into consideration for control have been explored.

Modelling and Control of Large Wind Power Plants

(Sven Erik Mattsson)

The objective of this work has been to give a global picture of the control problems of large horizontal axis wind power plants. The project was initiated during the design of a 3 MW wind power plant (WTS-3) in Sweden. The plant has been built in southern Sweden (Maglarp) and is operated by Sydkraft AB. The utility wanted to have a simulation model for design verification and failure detection. Moreover, a model suitable for future design of controllers was desired.

The dynamical models of the different components have been derived from the literature. The interactive simulation package Simnon has been used extensively. The total model is highly modularized to allow easier verification and extensions. The complex simulation model has been used together with mathematical analysis in order to achieve a better understanding for its behaviour.

A validation of the model has been made indirectly, using data from Maglarp. The identification package Idpac was used to analyse the data. Thus models for different parts of the plant could be verified. Since model building from identification is by no means trivial the interactive facilities in the packages were invaluable.

The control system has been synthesized. Compensation for varying wind speeds is crucial. Control authority and measurements are of course included into the design, and the interaction between process design and controller design are considered in detail. A design procedure for pitch angle control has been proposed, based on the LQG framework.

Nuclear Reactor Surveillance

Fault Detection in Boiling Water Reactors by Noise Analysis

(Sten Bergman, K J Åström)

The goal of this project has been to develop methods for detection of abnormal operation, defined by noise pattern changes in a nuclear reactor. The operator can be supported with a diagnostic capability related to the cause and effects of different failures.

The power reactor noise is strongly related to several variables. Thus a change in a noise source of a transfer function is not trivially related to specific causes. A more elaborate identification of the inherent transfer functions has to be performed. By using fault detection methods a sample pattern can be recognized as belonging to normal or abnormal categories. These methods can be implemented recursively.

A knowledge-based expert system for detection of abnormal operation has been proposed. A number of rules have been formulated and a search is made for the most probable event. A prototype system for local data acquisition and remote fault analysis has been built up to test the ideas.

Reactor Noise Analysis

(Sten Bergman)

Surveillance of nuclear reactors using noise signals have been highly recommended and a number of monitoring concepts have been reported during the last years.

This work addresses the Boiling Water Reactor noise problem from a simplified theoretical and a signal analysis point of view and discusses the use of noise for surveillance and diagnostics. The work has two parts. The first one describes the process, the noise sources and experimental analysis while the other addresses surveillance aspects, fault detection and the use of expert systems for diagnostics. Boiling water reactor noise as a phenomenon is described. The noise characteristics has to be related to various sources. Different identification methods are used to characterize the noise. In the second problem area reactor noise analysis is used for malfunction detection and the potential of using expert systems is considered. Problems to extract different features, make symbolic transformations or integrate different sources of knowledge for malfunction classification and fault detection are also considered.

Modelling and Simulation of Stone-Condenser Dynamics

(Sten Bergman, Per Persson)

A special law requires that the large nuclear reactor in Barsebäck is supplied with equipment for filtered venting of the reactor containments in case of a reactor accident. The design of a packed-bed thermal stone condenser is currently under way. In this project a modelling and simulation study of the condenser and its subsystems has been performed. The goal of this study was to model and simulate the global dynamics after a severe reactor accident, and analyse the effect of different valves for the stone condenser protection. A simulation model in Simnon was developed. The condenser and containment models were partly validated against other simulations and experiments.

4. LABORATORY

The laboratory has been reorganized and the department secured new space. Thus it has been possible to separate educational and research laboratories.

Research Laboratory

The Vax System

The Vax 11/780 system has been in operation since September 1980 and has gradually been extended to meet the increasing demands. The current configuration includes

Main memory 4 Mb
Disk memories 700 Mb
Terminal ports (48)
Tape drive
Computer image handling equipment (Matrox RGP-Graph)
A/D, D/A converters
Printers (Oki 2410, Oki DP250)
Canon Printer

For image processing purposes a video camera is connected to the Vax and to the Matrox system.

The Vax runs under the VMS operating system. However, the Vax is equipped with a Eunice system as well, which means that software can be executed in Unix environment. The software includes compilers for Fortran, Pascal, Lisp, Prolog, C and Modula. The interactive packages (see below) Simnon, Idpac, Modpac, Synpac, Polpac and Pcalc are also used extensively. Recently the formula manipulating package Macsyma was obtained as well as the control engineering package Ctrl-C.

The department itself has been actively developing facilities for word processing, using the Vax. Available commercial software did not fit our requirements for technical text, and a report generating software has been gradually developed. This allows a good compromise between flexibility and simplicity. The TeX system is also available but hitherto used only by specialists.

Educational Laboratory

Linear Systems Courses

Eight Apple IIe systems with diskettes have been interfaced to tank processes for level control, see Section 2. The systems have been used successfully in the basic undergraduate courses, but also allow investigation of simple autotuners. The software is mainly written in Basic, which allows simple graphics.

Real Time Programming

Since 1976 four LSI-11 systems have been used extensively in the real time programming courses. Still, the systems are surprisingly modern, even if the graphics are limited. The real time programs are written in Pascal, extended with a real time kernel. The LSI-11 systems will be replaced in 84/85 with modern and more powerful systems.

Two IBM PC systems, supplied with process interfaces, are used in the courses. A Modula-2 compiler extended with a real-time kernel written in Modula-2 has been used in real time programming.

Other Equipment

The teaching laboratory is further equipped with

* A process for demonstration of mixing control with possibilities for transport delay and reflux.

* A "coupled drive apparatus" from Tequipment Ltd for demonstration of tension and speed control of e.g. a roll of paper in a press or a paper machine.

* A number of standard PID controllers.

* A Lego plant. This is a process, built up of Lego toy bricks, that simulates discrete manufacturing of cars. Simple Lego cars are mounted from buffer storages along a production line. The plant can be controlled from a programmable logical controller.

* A sorting process from Tequipment Ltd. This equipment is used for sequencing control. The purpose is to sort a stream of coloured balls into different buffers.

* The "ball-and-beam process". The process consists of a horizontal beam with a ball balancing along it. The beam is controlled by a DC motor. The system has been used extensively in real time programming as well as for testing new control ideas.

* A "turtle" to simulate moving robots. The turtle is equipped with touch sensors and wheels as well as control signal interface. The turtle is used in the image processing project.

* The "Ilon" car, a little vehicle equipped with special wheels that allows the vehicle to turn into any desired direction. The vehicle is used in the image processing project.

Interactive Software

The department has developed extensive software for interactive simulation, analysis, identification and synthesis of control systems. The software has been packaged suitably into the following software packages:

Intrac A common user interface for all the packages;

Idpac For data analysis and identification of linear systems having one output and many inputs;

Modpac Package for model analysis, like matrix and polynomial operations used for transformations between frequency and time domains, continuous and time discrete models, transformations of state equations, Kalman decomposition and observer calculation;

Simnon Package for interactive simulation of nonlinear continuous time and/or discrete time systems. The package includes noise generators, time delays, a facility for using data files from Idpac as inputs to the system, and an optimizer;

Synpac A state oriented design package, that includes facilities for calculating state feedback and Kalman filters for continuous and discrete time LQG problems;

Polpac A polynomial oriented design package for multi-input single-output systems, including algorithms for pole placement, minimum variance control and LQG control.

A. List of Personnel

Professor

Karl Johan Åström

University lecturers (Universitetslektorer)

Gustaf Olsson
Björn Wittenmark

Acting (part time) university lecturers

Rolf Johansson
Matz Lenells

Docent

Per Hagander

Research engineers (Forskningsingenjörer)

Leif Andersson
Rolf Braun
Tomas Schönthal (programmer), on leave Jan-83 - Jan-84

Research assistants (Forskningsassistenter)

Sten Bergman (PhD candidate) until April-84
Hilding Elmqvist (PhD)
Tommy Essebo (programmer) until Sept-83
Per-Olof Gutman (PhD) until Jan-84
Tore Hägglund (PhD since Feb-84)
Matz Lenells (PhD since Jan-83) until Aug-83
Sven Erik Mattsson (PhD candidate)
Lars Nielsen (PhD candidate)
Anders Wikström until Sept-83
Ann-Britt Östberg

Teaching assistants (Assistenter)

Jan Peter Axelsson (PhD candidate)
Rolf Johansson (PhD since May-83)
Mats Lilja (PhD candidate)
Lars Malmheden (PhD candidate) from Aug-83
Bengt Mårtensson (PhD candidate) until Aug-83
Per Persson (PhD candidate) from Aug-83
Lars Rundqwist (PhD candidate)
Karl-Erik Årzén (PhD candidate)

Visiting scientists (Gästforskare)

Stanley Lee, Kansas State University, Dept of Industrial Engineering, Kansas (Oct 1 - Dec 3, 1982).

Wassim Badran, University of Oxford, Dept of Engineering Science, Oxford (Nov 2-30, 1982).

J D Aplewich, Univ of Waterloo, Dept of Electrical Engineering, Waterloo, Canada (May - Aug, 1983).

Cheng Chew Lim, Univ of Singapore, Dept of Electrical Engineering, Singapore (May 24 - June 12, 1983).

John Anton, Systems Control Inc, Palo Alto, California (May 29 - June 11, 1983).

Eli Jury, Univ of Miami, Dept of Electrical and Computer Engineering, Florida, USA (June 22 - July 19, 1983, and June, 1984)

Hussein Youlal, LEESA, Faculté des Sciences, Rabat, Morocco (May 2 - Nov 1, 1984)

Charles E Rohr, University of Notre Dame, Dept of Electrical Engineering, Notre Dame, Indiana, USA (June 11 - July 12, 1984)

Technical drawings (Tekniskt biträde)

Britt-Marie Carlsson, on leave Aug-82 - Aug-83
Doris Nilsson

Secretaries (Sekreterare)

Eva Schildt
Agneta Tuszynski (part time)
Eva Dagnegård (part time), on leave Oct-82 - April-83

Typist (Skrivhjälp)

Iréne Jönsson (part time) Aug-82 - Nov-83

B. Published Papers and Conference Contributions

Åström K J: Stochastic control theory. Invited plenary paper, SIAM 30th Anniversary Meeting, USA.

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Åström K J: Computer aided design of control systems. INRIA, 6th Int Conf on Analysis and Optimization of Systems, Nice, France, June 1984.

Åström K J, Helmersson A: Dual control of a low order system. Proc Développement et Utilisation d'Outils et Modeles Mathématiques en Automatique, Analyse de Systemes et Traitement du Signal, Belle-Ile, France, Sept 13-18, 1982. Also in I D Landau (Ed): Outils et Modeles Mathematiques pour l'Automatique l'Analyse de Systemes et le Traitement du Signal. Editions du CNRS, Paris, 1983, Vol 3, pp 741-758.

Åström K J, Hägglund T: Automatic tuning of simple regulators for phase and amplitude margins specifications. IFAC Workshop on Adaptive Systems in Control and Signal Processing, San Francisco, June 20-22, 1983.

Åström K J, Wittenmark B: Computer-Controlled Systems - Theory and Design. Prentice-Hall, New Jersey, 1984.

Åström K J, Zhao-ying Z: A linear quadratic Gaussian self-tuner. Proc ISIS Workshop on Adaptive Control, Florence, Italy, October 27-29, 1982.

Axelsson J P, Hagander P, Mandenius C F, Mattiasson B: Computer control of sucrose concentration in a fermentor with continuous flow. Proc 1st IFAC Workshop on Modelling and Control of Biotechnical Processes, Helsinki, Finland, Aug 17-19, 1982.

Bergman S, Mattsson S E: Wind power plant modelling and simulation. Proc 5th Power Plant Dynamics, Control and Testing Symposium, March 21-23, 1983, Knoxville, Tennessee, USA.

Bergman S: Fault detection in BWR using noise analysis. Proc 5th Conf on Power Plant, Modelling, Simulation and Control, March 21-24, 1983, Knoxwille, Tennessee, USA.
Also in Proc 16th Informal Meeting on Reactor Noise, May 17-21, 1983, Budapest, Hungary.

Elmqvist H: A graphical approach for documentation and implementation of control systems. Proc 3rd IFAC/IFIP Symposium on Software for Computer Control, SOCOCO '82, Madrid, Spain, Oct 5-8, 1982.

Elmqvist H: Combining graphical descriptions and equations for dynamical modelling. 4th IASTED Int Symp Modelling and Simulation, Lugano, Switzerland, June 21-24, 1983.

Elmqvist H, Mattsson S E: Implementation of real-time facilities in Pascal. Proc 3rd IFAC/IFIP Symposium on Software for Computer Control, Madrid, Spain, Oct 5-8, 1982.

Elmqvist H, Mattsson S E: Implementing real-time facilities in Pascal. Pascal Newsletter, Oregon Software (2340 SW Canyon Road, Portland, Oregon 97201), No 7, 1983, pp 11-17.

Gutman P-O: On-line use of a linear programming controller. Proc 3rd IFAC/IFIP Symposium on Software for Computer Control, Madrid, Spain, Oct 5-8, 1982.

Gutman P-O, Hagander P: A new design of constrained controllers for linear systems. Proc 21st IEEE Conference on Decision and Control, Orlando, Florida, USA, Dec 8-10, 1982.

Hägglund T: Incubation time prediction in yoghurt manufacturing. 1st IFAC Workshop on Modelling and Control of Biotechnical Proceses, Helsinki, Finland, Aug 17-19, 1982.

Hägglund T: The problem of forgetting old data in recursive estimation. IFAC Workshop on Adaptive Systems in Control and Signal Processing, San Francisco, June 20-22, 1983.

Johansson R: Parametrizations of linear multivariable systems for adaptive controllers. Proc 21st IEEE Conf on Decision and Control (CDC), Orlando, USA, Dec 1982.

Johansson R: Lyapunov functions for adaptive systems. Proc 22nd IEEE Conf on Decision and Control, San Antonio, USA, Dec 14-16, 1983.

Mattiasson B, Mandenius C-F, Axelsson J P, Danielsson B, and Hagander P: Computer control of fermentations with biosensors. in K Venkatasubramanian (Ed): Biochemical Engineering III, St Barbara, Sept 19-24, 1982, Proc NY Acad Sci.

Mayne D Q, Åström K J, Clark J M C: A new algorithm for recursive estimation of parameters in controlled ARMA processes. Report Imperial College of Science and Technology, January 1984. To appear in Automatica.

Olsson G: Control strategies for the activated sludge process. Chapter 30 of Comprehensive Biotechnology, Volume 3, Pergamon Press, 1983.

Olsson G: A common data base system for wastewater treatment evaluation. Paper, International Association on Water Pollution Research and Control, Workshop on Design and Operation of Large Wastewater Treatment Plants, Vienna, Austria, September 1983.

Wittenmark B: Trends in design of digital control systems and applied system identification. Proc 1st IASTED Int Symposium on Applied Control and Identification, June 28 - July 1, 1983, Copenhagen, Denmark.

Wittenmark B: Simple PID self-tuners based on pole-placement. In Singh (Ed): Encyclopedia of Systems and Control, Pergamon Press (to appear).

Wittenmark B, Åström K J: Implementation aspects of adaptive controllers and their influence on robustness. Preprints 21st IEEE Conf on Decision and Control, Orlando, Florida, USA, Dec 8-10, 1982.

Wittenmark B, Åström K J: Self-tuning control. In Singh (Ed): Encyclopedia of Systems and Control, Pergamon Press (to appear).

C. Reports

Only a limited number of copies of our reports are available for sale from the Department. However, any of the listed publications may be borrowed through your library service or from the following libraries in Sweden:

Linköpings Universitetsbibliotek
Svensktrycket, S-581 83 Linköping

UB 2, Svenska Tryckavdeln.
Box 1010, S-221 03 Lund

Stockholms Universitetsbibliotek
Svenska Tryckavdeln., S-106 91 Stockholm

Kungliga Biblioteket
Box 5039, S-102 41 Stockholm

Umeå Universitetsbibliotek
Box 718, S-901 10 Umeå

Uppsala Universitetsbibliotek
Box 510, S-751 20 Uppsala

The reports in 1000- and 3000-series may be ordered from

Department of Automatic Control
Lund Institute of Technology
Box 118
S-221 00 Lund, Sweden

There is a copying and handling charge of between 30 and 150 SEK for each document. Invoice will be sent together with the ordered report(s).

Please be certain to include both the report number and the title.

Dissertations

TFRT-1023 Lenells M: Adaptive start-up control. Nov 1982.

TFRT-1024 Johansson R: Multivariable adaptive control. April 1983.

TFRT-1025 Hägglund T: New estimation techniques for adaptive control. Dec 1983.

Final Reports

TFRT-3168 Åström K J: A Simnon tutorial. Oct 1982.

TFRT-3169 Åström K J: Reglerteknik - En elementär introduktion. Kapitel 3, Processmodeller (Control engineering - An elementary introduction. Chapter 3, The Process Models). Jan 1983.

TFRT-3170 Åström K J: Reglerteknik - En elementär introduktion. Kapitel 7, Olinjär koppling av enkla regulatorer (Control engineering - An elementary introduction. Chapter 7, Nonlinear coupling of simple regulators). March 1983.

TFRT-3171 Åström K J: Reglerteknik - En elementär introduktion. Kapitel 6, Linjär koppling av enkla regulatorer (Control engineering - An elementary introduction. Chapter 6, Linear coupling of simple regulators). Febr 1983.

TFRT-3173 Åström K J: En elementär introduktion. Kapitel 8, Dödtidskompensation (Control engineering - An elementary introduction. Chapter 8, Smith's predictor. March 1983). Oct 1983.

Activity Reports

TFRT-4012 Åström K J, Dagnegård E: Activity Report 1980-1982. Oct 1982.

Master Theses

TFRT-5278 Henriksson J: PI-algoritmer vid digital reglering (Digital algorithms for PI-control). Aug 1982.

TFRT-5279 Fohlin G: Mätvärdesinsamling med mikrodator utförd på en margarinprocess (Microcomputerbased data collection system for a margarin process). Aug 1982.

TFRT-5280 Rignell M: Tredimensionell datorgrafik och animering av industrirobot (Three dimensionel computer graphics and animation of an industrial robot). Sept 1982.

TFRT-5281 Jönsson H-Å, Svensson K: Styrning av fiberutläggning (Control of fiberdistribution in insulation material). Aug 1982.

TFRT-5282 Andersson F, Lindh G: Självinställare baserade på gradientmetoder (Self-tuning regulator based on gradient methods). Sept 1982.

TFRT-5283 Palmgren M: En självinställande PID-regulator för system med variabel tidsfördröjning (A self-tuning PID-regulator for systems with variable time delay). Sept 1982.

TFRT-5284 Hansson L: Studier av syre-reglering i biologisk avloppsrening (Studies of Dissolved Oxygen Control in Biological Wastewater Treatment). Sept 1982.

TFRT-5285 Svensson P-E: Experiment med en linjär-kvadratisk självinställare (Experiments with a linear-quadratic selftuner). Sept 1982.

TFRT-5286 Lund M: Neutronflödesystem med SPN-detektorer. Kompensering för neutronaktiveringseffekter med datoriserad signalbehandling (Neutron flux monitoring system based on SPN-detectors. Compensation for effects due to neutronactivation by computerized signal processing). Oct 1982.

TFRT-5287 Andersson K: Uppbyggnad av en digital bilhantering i ett svepelektronmikroskop (Subroutines for taking up and displaying pictures from a computer controlled scanningelectronmicroscope. Oct 1982.

TFRT-5288 Kai Siew W: Methods for Automatic Tuning of PID Regulators. Dec 1982.

TFRT-5289 Giver S: Modell och styrning av tvåmotorprocess med kopplade likströmsmotorer (Model and control of process with coupled DC-motors). Sept 1983.

TFRT-5290 Delacour O: Elektroniska bromssystem - en lämplighetstest (Electronic airbrake systems - A feasibility study). Febr 1983.

TFRT-5291 Möllerström A: Referat av handbok för TA 6500 mikrodatorbaserad reglerenhet. Undersökning av några olika inställningsregler för PI-regulatorer (Handbook for TA 6500 microprocessor control unit and investigation of some tuning rules for PI-controllers). March 1983.

TFRT-5292 Nilsson K: Analys och syntes av en Industrirobots dynamik (Analysis and syntesis of the dynamics of an industrial robot). March 1983.

TFRT-5293 Hansson L G: En självinställande regulator för frekvensreglering av kraftsystem med högspänd likström (A self-tuning regulator for frequency control of power systems with high voltage direct current). March 1983.

TFRT-5294 Tocaj R: Ellipsoidmetoden: Khachijans Algoritm för linjär programmering (The Ellipsoid method: Khachijans algorithm for linear programming). April 1983.

TFRT-5295 Rasmusson U: Simulerng av dynamiken i en kokarreaktor (Simulation of boiling water reactor dynamics). April 1983.

TFRT-5296 Persson P: Simulering och feldetektering i ett ventilservo för tryckreglering av en kokarreaktor (Simulation and faul-detection of a pressure control servosystem in a Boiling Water Reactor). April 1983.

TFRT-5297 Salmi M: Temperaturreglering av torkprocess med digital regulator (Temperature control of a drying process with a digital controller). May 1983.

TFRT-5298 Olsson J: Reglerad peroxidmiljö i en mikrobiell process (Controlled peroxid level in a microbial process). May 1983.

TFRT-5299 Wingertz B: Practical Aspects on Self Tuning Regulators. May 1983.

TFRT-5300 Falkvall K: LQG-regulator för flygplan (LQG-controller for an aircraft). June 1983.

TFRT-5302 Hall L: Modellbyggnad och simulering av klimat i stallbyggnader (Dynamic modelling and simulation of barn climate). Sept 1983.

TFRT-5303 Knutsson S: En självinställande prediktor med operatörskommunikation skriven i Omsi-Pascal (A self-tuning predictor with operator communication written in Omsi-Pascal). Oct 1983.

TFRT-5304 Bengtsson B-Å: Simulering av produktflöden (Simulation of product flow). Oct 1983.

TFRT-5305 Beskow Ch: Working on the airbus A310 flight management computer system. Dec 1983.

TFRT-5306 Pourchafai Mohammad-Reza: Styrning av pelletmaskin (Control of pelleting machine). Dec 1983.

TFRT-5307 Johansson K: Ett exempel på robotpositering med hjälp av videokamera (An example of robot positioning using a video camera). Jan 1984.

Reports of Master Theses

TFRT-6013 Wittenmark B: Master theses in Automatic Control. Dec 1983.

TFRT-6014 Wittenmark B: Master theses in Automatic Control. Jan 1984.

Internal Reports

TFRT-7246 Mannerfelt C F: A self-tuning regulator for systems with known dynamics and unknown disturbance characteristics. Aug 1982.

TFRT-7247 Axelsson J P, Hagander P, Mandenius C F, Mattiasson B: Computer control of sucrose concentration in a fermentor with continuos flow. Oct 1982.

TFRT-7248 Bergman S, Mattson S-E: Wind power plant modelling and simulation. Jan 1983.

TFRT-7249 Åström K J, Helmersson A: Dual control of a low order system. Febr 1983.

TFRT-7250 Bergman S, Åström K J: Fault detection in boiling water reactors by noise analysis. Febr 1983.

TFRT-7251 Åström K J: Computer aided modeling, analysis and design of control systems - A perspective. Febr 1983.

TFRT-7252 Bergman S: Reactor noise surveillance by parameter estimation and pattern recognition methods. Febr 1983.

TFRT-7253 Åström K J, Hägglund T: Automatic tuning of simple regulators for phase and amplitude margins specification. April 1983.

TFRT-7254 Hägglund T: Recursive least squares identification with forgetting of old data. March 1983.

TFRT-7255 Åström K J: LQG self-tuners. July 1983.

TFRT-7256 Åström K J: Implementation of an auto-tuner using expert system ideas. July 1983.

TFRT-7257 Åström K J: Analysis of Rohrs counterexamples to adaptive control. Aug 1983.

TFRT-7258 Mattsson S-E: Analysis of the control problem for horizontal axis wind turbines. Aug 1983.

TFRT-7259 Åström K, Åström K J: A PC implementation of a PID regulator. Sept 1983.

TFRT-7260 Lenells M: Utvärdering av vindmodeller för energiprognoser (Evaluation of wind models for power load predictions). Aug 1983.

TFRT-7261 Nielsen L, Elmqvist H: An image laboratory. Sept 1983.

TFRT-7262 Bergman S, Persson P: Modeling and simulation of stone-condenser dynamics during a reactor accident. Oct 1983.

TFRT-7263 Rundqvist L: Tryck- och syrereglering på Käppala-verket, dokumentation av reglerprogram i Novatune versionsdatum 83-11-22 (Pressure and dissolved oxygen control at Käppalaverket, version 83-11-22). Nov 1983.

TFRT-7264 Elevitch C: An approximate analytic control law for an active suboptimal dual controller. Nov 1983.

TFRT-7265 Nielsen L: Optimal digitization of 2-D images. Nov 1983.

TFRT-7266 Wittenmark B: Design of digital controllers - The servo problem. Dec 1983.

TFRT-7267 Wittenmark B: Sampling of a system with a time delay. Jan 1984.

TFRT-7268 Wittenmark B, Åström K J: Practical issues in the implementation of self-tuning control. March 1984.

TFRT-7269 Åström K J, Hägglund T: Automatic tuning of simple regulators. March 1984.

TFRT-7270 Hägglund T: Adaptive control of systems subject to large parameter changes. March 1984.

TFRT-7271 Åström K J, Anton J: Expert control. March 1984.

TFRT-7272 Wittenmark B: Analysis and design of control systems using CTRL-C. June 1984.

Travel Reports

TFRT-8038 Bergman S: Travel report - Safecomp 82 - Second International Workshop on Safety and Reliability of Industrial Computer Systems. Oct 1982.

TFRT-8039 Åström K J: Besök på Brown University (Visit at Brown University). May 1982.

TFRT-8040 Åström K J: Trip to Boston for participation in CACSD'83. May 1984.

D. Courses and Seminars at the Department

Undergraduate courses, graduate courses, seminars as well as extension courses, given at the department during the year, are summarized here. They are given both by the staff at the department and by invited lecturers.

Undergraduate Courses

Automatic control, linear systems (Reglerteknik AK)
Automatic control for chemical engineers (Reglerteknik MK)
Principles of automatic control (Reglerteknikens grunder)
Computer controlled systems (Datorstyrda reglersystem)
Systems engineering (Systemteknik)
Computers in control systems (Datorer i reglerteknik)
Applied real-time programming (Tillämpad realtidsprogrammering)

PhD Courses

The following courses have been given:

	1982-83
Stochastic control 6p (B Wittenmark)	Aug - Dec
Linear systems 8p (P Hagander)	Jan - May
Adaptive control 8p (K J Åström)	Jan - May
AI for engineering applications 2p (J Anton)	May 5 - June 10
Computer control theory 2p (B Wittenmark, K J Åström)	March-April
	1983-84
Synthesis 8p (P Hagander)	Oct - Dec
Linear systems 8p (P Hagander)	Oct - Feb

Seminars

1982

Aug 19	Y Bar-Shalom (Univ of Connecticut): A multiple model adaptive dual control algorithm for stochastic systems.
Aug 25	C R Johnsson (Cornell University): On adaptive control and communication theory.
Sept 2	G Karlsson, S Nilsson (Lund): Off-line programmering av Asea-robot i högnivåspråk (Off-line high level programming of the Asea robot).
Oct 15	O Permvall (Lund): Franz Lisp (VAX-Lisp).

1982

Oct 29	M Lenells (Lund): Adaptive start-up control.
Nov 4	L Nielsen (Lund): Discussion of real-time AI with data driven function of merit in connection with the SISO controller.
Nov 10	K J Åström (Lund): Hur kan regelbaserade expertsystem och metoder från AI användas i reglersystem? (Some preliminary thoughts on expert control and AI in control applications?).
Nov 11	W Badran (Oxford Univ): A new approach to pH control.
Nov 24	K Glover (Oxford Univ): Balanced realisations.
Dec 20	H Elmqvist (Lund): Presentation av LICS (Presentation of LICS).

1983

Feb 14	L Gustafsson (Luleå Tekniska Högskola): Grundutbildning och forskning i industriell elektronik vid högskolan i Luleå; dagsläge och framtidsutsikter (Education and research on industrial electrical engineering at the Luleå Institute of Technology).
Feb 14	A Lundberg (Luleå Tekniska Högskola): Utveckling av ett styr-system för industrirobot; ett projektarbete för teknologerna i sista årskursen på Industriell elektronik vid högskolan i Luleå (Development of a sequencing control system for an industrial robot; A student project at the Luleå Inst of Techn).
April 12	K J Åström (Lund): Dimensionering av servomekanismer (Synthesis of servo systems).
April 14	J Cassidy (General Electric Co, Schenectady): Control engineering aspects of industrial robots.
April 18	A Benveniste (IRISA, France): Detection of abrupt changes in dynamical systems, with applications to speech segmentaation.
April 19	K J Åström (Lund): Analys av Rohrs motexempel mot adaptiv reglering Analysis of the Rohr counter example in adaptive control).
April 25	D Mellichamp (Univ of California, Santa Barbara): Adaptive control of a tubular autothermal reactor.
May 6	S Bergman (Lund): Resumé - 5th Power Plant Modelling, Simulation and Testing Symposium.
May 26	J D Aplevich (Univ of Waterloo, Canada): Some properties of implicit linear systems.
June 3	F E Cellier (ETH, Zurich): Computer-aided design of control systems.

1983

June 6 — M Wonham (Univ of Toronto): Supervisory control of discrete event systems.

Aug 25 — Z D Yuan (LiTH and East China University): Properties of nonparametric time-domain methods for estimating transfer functions.

Aug 26 — D Wiberg (UCLA): Introduction to lattice algorithms.

Aug 26 — L Johnsson (Caltech): VLSI implementations.

Sept 9 — J Alvarez & R Lozano (Inst Polytech National, Mexico City): Activities in control at the Centro de Investigacion y de Estudios Avanzados, IPN, Mexico.

Sept 21 — B Liebst (Univ Minnesota): Optimized pitch controller for load alleviation on wind turbines.

Sept 28 — J Berglind: NIMBI - Ett desillusionerande försök att använda AI på ett Nim-liknande spel (NIMBI - A non-successful attempt to apply AI for a Nim-like game).

Oct 10 — K J Åström & H Elmqvist (Lund): Intryck från Boston (Travel report from Boston).

Oct 26 — L Bååth (Facit): NAF's system SDM-20.

Oct 28 — L Rundqvist & M Lilja (Lund): H^{∞}-optimal reglering a la Francis/Zames. Introduktion till LiTH-kursen (Introduction to a course on H^{∞}-optimal control).

Nov 10 — S E Mattsson (Lund): Vindkraftdesign (Design of wind power).

Nov 18 — J Sternby & K J Åström (Lund): PID-servo synthesis.

Nov 18 — L Nielsen (Lund): Presentation av "Visual Servolab". Nuläge och idéer (Presentation of the status of the Visual Servo Laboratory equipment).

Dec 9 — R Johansson (Lund): Liapunovfunktioner för adaptiva system (Lyapunov function for adaptive systems).

1984

Jan 9 — B Mårtensson (Lund): Olinjär reglerteknik, differential geometri och Lie algebra (Nonlinear control, differential geometry and Lie algebra).

Jan 9 — K J Åström & R Johansson (Lund): Intryck från USA (Travel report from USA).

Jan 13 — B Wittenmark (Lund): En julnöt (Take home problem solved during Christmas).

1984

Feb 10	T Söderström (Teknikum, Uppsala): Instrumental variable identification.
Feb 9	B Wittenmark & G Olsson (Lund): Information from USA.
March 2	K J Åström (Lund): Varför en reglertekniker behöver vara tekniskt allmänbildad och hur man blir det. Programmera mera - ny policy. Programs from heaven (How to be a good control engineer - a personal view).
March 9	E Trulsson (LiTH): Control based on explicit criterion minimization.
March 30	L Rundqvist (Lund): Presentation of Novatune.
March 30	H Elmqvist (Lund): Objektorienterad programmering (Object oriented programming).
April 5	J Oppelstrup (ITM): Numeriska metoder - integrationsmetoder (Numerical integration algorithms).
April 9	G Björkman (Ericsson, Mölndal): Programvarumetodik (Software engineering).
April 10	G Björkman: Programvarumetodik, några exempel från Ericsson koncernen. (Software engineering, some applications from Ericsson).
April 10	H Thilderqvist (SATTControl): PC-programmering på SATT (PC programming at the SATT Company).
April 11	M Millnert (LiTH): Identification and control of systems subject to abrupt changes.
April 12	M Davies (Imperial College, UK): Piecewise deterministic Markov processes: Modelling and optimal control.
April 17	S Bergman (Asea, Västerås): Reläforskning på Asea (Relay research of Asea).
April 24-27	T Glad (LiTH): Robusthet och olinjära regulatorer (Robustness and nonlinear controllers). Four seminars.
May 21	K J Åström & B Wittenmark (Lund): Regulatorns väg från idé till anläggning (From idea to an industrial product - the development of a controller).
May 9	T Schönthal (Lund): Datorgrafik (Computer graphics).
May 9	M Lilja (Lund): Travel report from The Netherlands.
May 14	L Praly (Ecole de Mines de Paris): On the role of parameters and filters in robustness of adaptive control schemes.

1984

May 14-17	B von Sydow (LuTH): Teorier för realtidsspråk (Theories on real time languages).
June 4	K J Åström m fl (Lund): How to code a self-tuning regulator.
June 5	K J Åström m fl (Lund): Lisp som Intrac (Using Lisp to implement Intrac).
June 7	J P Axelsson & P Hagander (Lund): Etanol och jästproduktion, syresättning med H_2O_2 (Ethanol and baker's yeast production oxygenation with H_2O_2).
June 7	N Munro (UMIST): Computer aided design.
June 7	E Jury (Univ of Miami): Stability independent and dependent of delay for delay differential systems.
June 13	C Rohrs (Notre Dame): An interesting non-linear system associated with adaptive control.
June 14	C Rohrs: Conditioning a plant for frequency selective adaptive control with improved robustness.
June 18	P Thompson (Caltech): Overview and demo of design package CC.

Extension courses

The extension program in automatic control offers courses for extended education of engineers in industry.

The following courses have been given during the considered period

Digital Control	Aug 31 - Sep 2, 1982
Digital Control	Sep 7 - Sep 9, 1982
Survey of Control Theory*)	Sep 13 - Sep 17, 1982
Digital Control	Jan 25 - Jan 27, 1983
Digital Control	Feb 1 - Feb 3, 1983
Digital Control	Sep 20 - Sep 22, 1983
Digital Control	Sep 27 - Sep 29, 1983
Survey of Control Theory	Jan 30 - Feb 2, 1984
Simulation	Apr 3 - Apr 5, 1984
Adaptive Control	May 22 - May 24, 1984

All courses demand 3-4 days of attendance and take 16-20 participants.

The participants receive some material for preparation when they sign up for the course. One textbook and a file with several hand-outs are included in the price.

Each day of a course usually consists of two or three lectures and one laboratory session of about three hours.

*) Special course for the power industry

The course on digital control and the survey course have their counterparts among the elementary courses. The course on simulation is centered around the simulation language Simnon with many exercise sessions.

The course on adaptive control was developed under the direction of Rolf Johansson during spring 1984. Several new laboratory exercises have been organised for this course. There is one laboratory exercise based on the autotuner and implemented on Apple IIe by Tore Hägglund and Karl Johan Åström. Another exercise is based on Asea Novatune and has been developed by Lars Rundqwist. Rolf Johansson has implemented an adaptive regulator on LSI-11 for which there are also some laboratory exercises.

The management of the courses has been under the direction of

Per-Olof Gutman	- December 1982
Matz Lenells	January 1983 - June 1983
Rolf Johansson	July 1983 -

Mrs. Ann-Britt Madsen of the university administration office is in charge of liaison with education offices of corporations and organisations.

A special four day course on the programming language Ada was arranged by CID on May 2-5, 1983, in cooperation with J & B Agerberg, Stockholm. Both theoretical lectures and computer exercises on work stations (Western Digital Micro Engine) were arranged.

E. Lectures by the Staff

1982

July 19	Åström K J: Adaptive control. Systems Control Technologies, Palo Alto, California.
July 21	Åström K J: Stochastic control theory. Invited plenary lecture at SIAM 30th Anniversary Meeting, Stanford University, Palo Alto, California.
Aug 19	Axelsson J P: Computer control of sucrose concentration in a fermentor with continuous flow. 1st IFAC Workshop on Modelling and Control of Biotechnical processes, Helsinki, Finland.
Aug 19	Hägglund T: Incubation time prediciton in yoghurt manufacturing. 1st IFAC Workshop on Modeling and Control of Biotechnical Processes, Helsinki, Finland.
Aug 24	Elmqvist H: Activities at Center for Industrial Computer Systems. RDF Symposium on Research in Information Processing Riksdataförbundet, Stockholm.
Sept 13	Åström K J: Dual control of low order systems. CNRS colloquium Développement et Utilisaation d'Outils et Modeles Mathématiques en Automatique, Analyse de Systemes et Traitement du Signal, Belle Ile, France.
Oct 4	Wittenmark B: Signalbehandling och regleralgoritmer (Sampled data systems and digital controllers). STF Course Mikrodatorbaserade reglersystem, Oxelösund, Sweden.
Oct 6	Gutman P-O: On-line use of a linear programming controller. 3rd IFAC/IFIP Symposium on Software for Computer Control, Madrid, Spain.
Oct 6	Elmqvist H: A graphical approach for documentation and implementation of control systems. 3rd IFAC/IFIP Symposium on Software for Computer Control, Madrid, Spain.
Oct 7	Elmqvist H: Implementation of real-time facilities in Pascal. 3rd IFAC/IFIP Symposium on Software for Computer Control, Madrid, Spain.
Oct 19	Åström K J: Dual control theory. Technical University of Trondheim, Trondheim, Norway.
Oct 19	G Olsson: Municipal wastewater treatment in Sweden. Instrument Society of America, Annual Conference, Philadelphia, USA.

1982

Oct 21	Olsson G: Dynamic modelling, identification and control of activated sludge systems. Department of Environmental Engineering, Rice University, Houston, Texas, USA.
Oct 25	Olsson G: Dynamic modelling of clarifier dynamics. Wastewater Technology Centre, Burlington, Ontario, Canada.
Oct 27	Åström K J: A linear quadratic Gaussian selftuner. ISIS Workshop on Adaptive Control, Florence, Italy.
Dec 3	Wittenmark B: Sampled data control - Synthesis methods. University of Connecticut, Storrs, USA.
Dec 7	Hagander P: A new design of constrained controllers for linear systems. 21st IEEE Conf on Decision and Control, Orlando, Florida, USA.
Dec 8	Johansson R: Parametrizations of linear multivariable systems for adaptive controllers. 21st IEEE Conf on Decision and Control, Orlando, Florida, USA.
Dec 8	Wittenmark B: Implementation aspects of adaptive controllers and their influence on robustness (invited paper together with K J Åström). 21st IEEE Conf on Decision and Control, Orlando, Florida, USA.

1983

Feb 14	Elmqvist H: Modern man-machine communication - implementation of control systems. Teli, Nynäshamn, Sweden.
Feb 15	Elmqvist H: Modern man-machine communication - implementation of control systems. Datema Process Data, Nynäshamn, Sweden.
March 1-3	Åström K J: Short course on adaptive control. Research Institute of National Defense (FOA), Stockholm, Sweden.
March 7	Olsson G: Processreglering i reningsverk (Process control in wastewater treatment). Svenska Teknologföreningen, Avesta, Sweden.
March 14-18	Åström K J: Control theoretical and engineering results on adaptation. 4 lectures, Spring Course on Adaptation and Optimization, International Institute for Applied Systems Analaysis (IIASA), Laxenburg, Austria.
March 15	Elmqvist H: Modern man-machine communication - implementation of control systems. Boliden Systemex, Helsingborg, Sweden.
March 15	Mattsson S E: Modellering, simulering och reglering av vindkraftverk (Wind power plant modelling, simulation and control). National Wind Power Symposium, Stockholm, Sweden.

1983

March 22	Bergman S: Wind power plant modelling and simulation. 5th Power Plant Dynamics, Control and Testing Symposium, Knoxville, Tennessee, USA.
March 23	Bergman S: Fault detection in BWR using noise analysis. 5:th Conf on Power Plant, Modelling, Simulation and Control, Knoxwille, Tennessee, USA.
March 23-25	Åström K J: Short course on adaptive control. Research Institute of Defense (FOA), Stockholm, Sweden.
March 25	Bergman S: Transmitter modelling. Oak Ridge National Laboratories, Oak Ridge, USA.
March 31	Bergman S: Wind power plant modeling and simulation. Hamilton Standards, Connecticut, USA.
April 14	Elmqvist H: Modern man-machine communication - implementation of control systems. LiTH, Linköping, Sweden.
April 15	Elmqvist H: Modern man-machine communication - implementation of control systems. KTH, Stockholm, Sweden.
April 18	Wittenmark B: Signalbehandling och regleralgoritmer (Sampled data systems and digital controllers). STF course on micro computers in control systems), Söderköping, Sweden.
May 6	Åström K J: Robustness issues in adaptive control. Westinghouse, Baltimore, USA.
May 10	Olsson G: Dynamics of clarifiers. Wastewater Technology Centre, Burlington, Ontario, Canada.
May 11	Olsson G: Adaptive control of dissolved oxygen. Wastewater Technology Centre, Burlington, Ontario, Canada.
May 12	Olsson G: Hydraulic propagation in treatment plants. Wastewater Technology Centre, Burlington, Ontario, Canada.
May 18	Bergman S: Fault detectioin in BWR using noise analysis. 16:th Informal Meeting on Reactor Noise, Budapest, Hungary.
May 9	Åström K J: Adaptive control, self-tuning and auto-tuning and overview. University of Maryland, USA.
May 10	Åström K J: Industrial applications of adaptive control - pitfalls and success stories. University of Maryland, USA.
May 20	Olsson G: Control of wastewater treatment processes, Experiences and Unsolved Problems. Nordisk Ministerrådsseminarium, Oslo, Norway.
May 25	Åström K J: Process control - past, present and future. ASEA Industrial Days, Stockholm, Sweden.

1983

May 25	Olsson G: Processreglering i reningsverk (Process control in wastewater treatment). Svenska Teknologföreningen, Avesta, Sweden.
June 15	Olsson G: Interactive identification and design of control systems. Weyerhaeuser Technical Centre, Weyerhaeuser Company, Tacoma, Washington, USA.
June 16	Olsson G: Modelling and process control in wastewater treatment. Weyerhaeuser Technical Centre, Weyerhaeuser Company, Tacoma, Washington, USA.
June 21	Åström K J: Automatic tuning of simple regulators for phase and amplitude margins specifications. IFAC Workshop on Adaptive Systems in Control and Signal Processing, San Francisco, USA.
June 21	Åström K J: LQG selftuners. IFAC Workshop on Adaptive Systems in Control and Signal Processing, San Francisco, USA.
June 21	Hägglund T: The problem of forgetting old data in recursive estimation. IFAC Workshop on Adaptive Systems in Control and Signal Processing, San Francisco, USA.
June 22	Elmqvist H: Combining graphical descriptions and equations for dynamical modelling. 4th IASTED Int Symp Modelling and Simulation, Lugano, Switzerland.
July 1	Hägglund T: The problem of forgetting old data in recursive estimation. USC, Los Angeles, USA.
July 1	Wittenmark B: Trends in design of digital control systems and applied system identification. IASTED Symposium of Applied Control & Identification, Copenhagen, Denmark.
Aug 31	Åström K J: Adaptive control - a survey. Sydkraft symposium on control of powersystems, Malmö, Sweden.
Sept 1-2	Åström K J: Process Control - Past, present and future. ASEA, Västerås, Sweden.
Sept 5-13	Åström K J: Modeling and simulation techniques, implementation of digital control laws. Stuttgart, Athens, Paris.
Sept 12	Olsson G: Processreglering i reningsverk (Process control in wastewater treatment). Svenska Teknologföreningen, Avesta, Sweden.
Sept 21	Åström K J: Utvecklingspotientialen inom elektronik och datateknik (Potential for development in electronics and computers). Paneldiskussion om industrins konkurrenskraft och tekniska nivå 1990 (Panel discussion about the industrial outlook for the 1990), Department of Industry, Stockholm, Sweden.

1983

Sept 28	Åström K J: Process control - past, present and future. ASEA, Västerås, Sweden.
Sept 30	Elmqvist H: A graphical system for modeling and implementation of control systems. Symposium on Computer-Aided Control Systems, MIT, Cambridge, USA.
Oct 4	Åström K J: Automatic tuning of simple regulators. MIT, Cambridge, MA.
Oct 19	Olsson G: Processreglering i avloppsreningsverk - erfarenheter och utvecklingsmöjligheter (Process control in wastewater treatment, experiences and potentials). Svenska Föreningens för Vattenhygien höstmöte, Örebro, Sweden.
Oct 26	Olsson G: Kontinuerliga regulatorer, regulatorstrukturer (Continuous controllers and control structures). SATTControl, Malmö, Sweden.
Nov 16	Åström K J: Metoder för automatisk inställning av PID regulatorer (Methods for automatic tuning of PID regulators), Luleå Institute of Technology, Luleå, Sweden.
Nov 16-17	Elmqvist H: LICS - A language for implementation of control systems. ASEA, Västerås, Sweden.
Nov 23	Åström K J: Adaptive control. SATT Electronics AB, Malmö, Sweden.
Nov 24	Olsson G: Reglering av biologiska reningsverk. Dagsläge och utvecklingstendenser (Controlling biological sewage works. State of the art and new developments). Technical symposium on "Modern techniques and future needs in water and wastewater engineering", Asea, Västerås, Sweden.
Dec 4	Åström K J: Self-tuning regulators. Lecture in graduate course, University of Illinois, USA.
Dec 5	Åström K J: Theory and applications of adaptive control. Coordinated Science Laboratory, University of Illinois at Urbana-Champaign, Illinois, USA.
Dec 5	Åström K J: Robustness of adaptive control, University of Illinois, USA.
Dec 13	Åström K J: Practical aspects on adaptive control. IEEE Tutorial Workshop on Adaptive Control, San Antonio, Tex.
Dec 15	Åström K J: Rohrs counterexample. 22nd IEEE Conf on Decision and Control, San Antonio, Texas, USA.
Dec 15	Johansson R: Lyapunov functions for adaptive systems. 22nd IEEE Conf on Decision and Control, San Antonio, Texas, USA.

1984

Jan 11	Åström K J: Automatic tuning of simple regulators. Benelux meeting on Systems Control, Lunteren, Holland.
Jan 11	Åström K J: Practical aspects on digital implementation of control laws. Benelux meeting on Systems Control, Lunteren, Holland.
Jan 11	Olsson G: Parameter identification of water quality data. Weyerhaeuser Company, Tacoma, Washington, USA.
Jan 16	Åström K J: Adaptive control - An overview. Int Workshop on Adaptive Control organized in honor of Professor Alexander Lerner's 70th birthday. Technion City, Haifa, Israel.
Jan 16	Åström K J: Practical aspects of adaptive control. Int Workshop on Adaptive Control in the honor of Professor Alexander Lerner's 70th birthday. Technion City, Haifa, Israel.
Jan 18	Hägglund T: Automatisk inställning av enkla regulatorer (Automatic tuning of simple regulators). Reglermöte 84, Göteborg, Sweden.
Jan 19-21	Åström K J: Analysis of Rohrs counterexample to adaptive control. Linköping Institute of Technology, Linköping, Sweden.
Jan 20	Åström K J: Practical aspects of adaptive control. Dept of Electrical Engineering, Linköping University, Sweden.
Feb 23	Hägglund T: New estimation techniques for adaptive control. Linköping Institute of Technology, Linköping, Sweden.
March 2	Olsson G: New trends in process control. Department of Chemical Engineering, University of Cape Town, Rondebusch, South Africa.
March 5	Olsson G: Estimation in biotechnical systems. Department of Chemical Engineering, University of Cape Town.
March 7	Olsson G: Control of wastewater treatment systems. Department of Civil Engineering, University of Cape Town.
March 14	Bergman S: Modelling, simulation and control of a 3-MW wind turbine. Energy Research Centre (ECN), Petten, Holland.
March 15	Olsson G: Dynamiska modeller för aktivslamprocesser. Reglering av aktivslamprocessen. Identifiering av dynamik i reningsverk. Rekursiv estimering av parametrar i reningsverk (Dynamical models for the activated sludge process. Control, identification, recursive estimation in wastewater treatment). Four seminars in a PhD Course, Tekniska Högskolan i Luleå, Sweden.

1984

March 16 — Nielsen L: Bildtolkning i ett exempel på robotpositionering med hjälp av videokamera (Image interpretation in an example of robot positioning with use of video kamera). SSAB Symposium on Image Analysis, Linköping, Sweden.

March 26 — Hagander P: Some experience with CAD packages of Lund. 1st IFAC Workshop on Systems Engineering Approaches in Control Engineering, Noordwijkerhout, Holland.

March 27 — Hagander P: Case study in control of fermentation processes. 1st IFAC Workshop on Systems Engineering Approaches in Control Engineering, Noordwijkerhout, Holland.

March 29 — Åström K J: Mina erfarenheter som Fosam forskare (My experiences as an industrial researcher). Skånska Ingenjörsklubben, Malmö, Sweden.

May 7 — Olsson G: Beskrivning av driftstörningar och reglering av reningsverk. Datoranvändning i reningstekniken, dagsläge och utvecklingstendenser (Operating disturbances and control in wastewater treatment. Application of computers, state of the art, new developments). Two seminars at the Spring Meeting, Värmlandskommunernas Va-driftgrupp, Kristinehamn, Sweden.

May 23 — Åström K J: Datorgrafik, reglerteknik (Computer graphics and automatic control). A meeting on High Technology at the Pacific Coast, IVA-SYD, Malmö, Sweden.

June 4 — Olsson G: Användning av datorer på en teknisk institution (Application of computers at a technical department). Discussion on computer use between the Copenhagen and Lund Universities, Malmö, Sweden.

June 12 — Åström K J: Towards intelligent control. Whitney Symposium on Science and Technology V "Intelligent Automation and Processing".

June 22 — Åström K J: Computer aided design of control systems. Invited conference, 6th Int Conf Analysis and Optimization of Systems, INRIA, Nice, France.

F. Travels

Karl Johan Åström visited USA on July 5-31, 1982. The main reason was to present an invited paper on Stochastic Control Theory at the SIAM 30th Anniversary Meeting. During the trip he also visited with prof R Bellman at USC, prof Polak at UCB, and prof Franklin and prof Kailath at Stanford. Moreover he visited Systems Control, where he lectured on Adaptive Control and discussed applications of AI to adaptive control. He also looked at work stations at SUN, Silicon Graphics, Corvus and Cromenco and at servo problems for Winchester drives at Cogito. On August 26 Åström visited DTH in Lyngby, Denmark, to be the outside examiner for the dissertation Ship Propulsion Losses related to Automatic Steering and Prime Mover Control by Mogens Blanke. Åström participated in the CNRS national colloquium on Developpement et Utilisation et Modeles Matematique, Analyse de Systemes et Traitment du Signal, Sept 13-17 at Belle-Ile, France, where he presented a paper. On Sept 30 - Oct 3, 1982, Åström visited Heidelberg. There he participated in the symposium in commemoration of 25 years with IFAC and in the meeting with the IFAC council. On Oct 18-20 Åström visited Technical University of Trondheim to be examiner of the dissertation Modelling and Control of Offshore Loading Systems by Hans-Roar Soerheim. He also gave a seminar. On Oct 26-29 Åström presented a paper at the Workshop on Adaptive Control in Firenze. Finally in 1982, he participated in 5th Int Conf on Analysis and Optimization of Systems in Paris on Dec 14-17.

In 1983, on March 14-18, Karl Johan Åström participated in IIASA Workshop on Adaptive Control in Wien, where he presented three lectures. On April 4-6 he participated in the Unilever Symposium on Future Directions in Manufacturing Technology, Port Sunlight Laboratory, Merseyside, UK. On May 2-13 Åström visited USA. There, he visited MIT and NSF to plan a joint NSF-STU workshop on adaptive control, he participated in the first meeting of the advisory group for the LIDS laboratory at MIT, and he visited University of Maryland and George Axelby at Westinghouse. On May 24-26 Åström visited Stockholm to participate in the ASEA industrial days and present a lecture. On June 13-23 he visited San Francisco to participate in the IFAC Workshop on Adaptive Control and present two papers. He also visited UC Berkeley to discuss with prof Polak, prof

Tomizuka and prof Auslander.

Åström made a trip to Stuttgart, Athens and Paris in September, 1983, to give lectures on modeling and digital control. He also went to Cambridge, Massachusetts, where he visited MIT and Harvard to participate in a CACSD symposium and to give seminars. In December he visited USA again to participate in the IEEE Conference on Decision and Control, Texas. En route he visited University of Illinois to discuss adaptive control, John Anton at Systems Control Inc to work on an expert control paper and Carver Mead at Caltec to discuss possible cooperation.

In January, 1984, Åström visited Holland to participate in a Benelux meeting on Systems and Operation Research. In January he also visited Israel to participate in a workshop on Adaptive Control on the honor of Professor Lerner's 70th birthday. In April he visited General Electric together with Leif Andersson for an in depth review of software for computer aided control system design.

Jan Peter Axelsson visited Helsinki in August 1982 to participate in the 1st IFAC Workshop on Modeling and Control of Biotechnical Processes.

Sten Bergman visited USA in March 1983. He participated in the 5th Power Plant, Modelling, Simulation and Control Conference March 21-24 in Knoxwille, Tennessee, where he presented a paper. He also visited Oak Ridge National Laboratories, Systems Control in Palo Alto, and Hamilton Standards in Connecticut. In May the same year Bergman visited Hungary. He first participated in the 16th Informal Meeting on Reactor Noise, May 17-21 in Budapest, where he presented a paper. Then he also visited Paks nuclear station.

On March 12-15, 1984, Bergman visited Energy Research Centre (ECN) in Petten, Holland.

Hilding Elmqvist visited USA July 24 - August 7, 1982, to participate in the conference and exhibition Siggraph '82 on computer graphics. He also visited Brown University, Apollo Computer Inc., and Computer Corporation of America. In October 1982 he visited Spain to participate in the 3rd IFAC/IFIP Symposium on Software for Computer Control. He also participated in the 4th IASTED International Symposium on Modelling and Simulation, June 21-24, 1983, in Lugano, Switzerland. In September 1983 he participated in the symposium Computer-Aided Control Systems Design at MIT and demonstrated LICS.

Per-Olof Gutman visited Madrid, Spain, October 2-9, 1982. On Oct 4 he met with Dr Manuel Armada at Instituto de Automatica Industrial, La Poveda, Madrid. Dr Armada and his group deal mainly with robotics, theoretical work on bilinear systems, and computer aided design. On October 5-8 he participated in the 3rd IFAC/IFIP Symposium on Software for Computer Control, where he presented a paper. On December 15 Per-Olof Gutman left Sweden for the Electrical Engineering Department, Technion - Israel Institute of Technology, Haifa, Israel, for a one-year post-doctoral stay, financed by the C F Lundström Foundation, Täby, the Swedish Board of Technical Development (STU), the Helge Ax:son Johnson Foundation, and Lund University.

Per Hagander visited Helsinki in August 1982 to participate in the 1st IFAC Workshop on Modeling and Control of Biotechnical Processes. In September he participated in the Meeting of Heads of University Control Engineering Groups in W. Europe held in Gent/Leuven, Belgium. He participated in the 21st CDC-conference in Orlando, Florida, in December 1982, and presented a paper coauthored by Per-Olof Gutman.

On March 26-28, 1984, Hagander participated in the 1st IFAC Workshop on Systems Engineering Approaches in Control Engineering, Noordwijkerhout, Holland, where he presented two papers.

Tore Hägglund visited Helsinki in August 1982 to participate in the 1st IFAC Workshop on Modeling and Control of Biotechnical Processes. He visited USA from June 18 to July 2, 1983. He participated in and presented a paper at the IFAC Workshop on Adaptive Systems in Control and Signal Processing, June 20-22. He also participated in the American Control Conference, June 22-24. During the stay in USA he visited University of California in Berkeley, Integrated Systems Inc., Stanford University, and University of Southern California in Los Angeles.

Hägglund visited France in March 1984, where he participated in the seminar "Developpement et Utilisation de Nouveaux Outils Mathematiques pour l'Automatique et l'Analyse de Systemes". He also visited IRISA in Rennes.

Rolf Johansson visited Department of Precision Instruments, Qing-Hua University, Beijing, China, in June 1982. In December 1982 he visited USA to participate in 21st IEEE Conference on Decision and Control, where he presented a paper.

Matz Lenells participated in a conference about computer graphic in Linköping in June, 1983. The conference is by and large documented by the book Datorgrafikdagar, edited by E Attebo et al.

Bengt Mårtensson has spent the year 1983/84 as a graduate student at Harvard University. He has also been taking courses at MIT. After the spring term he attended the American Control Conference (ACC) in San Diego June 6-8, and visited the following institutions: Rensellear Polytechnic Institute (RPI), Washington University in S:t Louis, University of Illinois at Champagne-Urbana, Stanford University, University of California at Santa Barbara (UCSB).

Sven Erik Mattson participated in the national wind power symposium at The Aeronautical Research Institute of Sweden, Stockholm, March 14-15, 1983.

Lars Nielsen visited Munich in October 1982 to participate in the 6th International Conference on Pattern Recognition (ICPR).

Gustaf Olsson participated in London Sept 27-29, 1982, in an international committee meeting on on-line instrumentation for wastewater treatment systems. The committee is a standing working group under the IAWPRC (Int. Association for Water Pollution Research and Control). He went to the USA between October 16 and 31 and participated in the Annual ISA conference, Philadelphia, and exchanged experiences and results with fellow researchers in Houston, Texas, and in Burlington, Ontario.

In May 1983 Gustaf Olsson visited Environment Canada for exchange of research results and cooperative efforts in wastewater treatment control. He was an invited speaker at a symposium in Oslo on May 20, 1983 on the theme "Demands in wastewater technology". He participated in the American Control Conference in San Francisco in June 1983. In November 1983 he was invited to lecture at a special symposium on Modern Technology and Future Demands in Wastewater Treatment at ASEA, Västerås, in connection with their 100 year anniversary. In January 1984 he visited Weyerhaeuser Company, Tacoma, and Environment Canada, Burlington, Ontario, for further research cooperation. He was invited to the University of Cape Town, South Africa in March 1984 to lecture at the Chemical and Environmental Engineering Departments. Later in March he gave a graduate course on Control in wastewater Treatment at the Luleå Institute of Technology.

Tomas Schönthal visited the 1982 Decus Europe Symposium held at Warwick University, England, Sept 6-10.

Björn Wittenmark participated at the CDC in Orlando in December 1982, where he presented an invited paper. At the visit in the USA he also lectured at University of Connecticut in Storrs.