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Activity Report: Automatic Control 1984-1985

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1985

Document Version:

Publisher's PDF, also known as Version of record

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Citation for published version (APA):

Wittenmark, B., & Dagnegård, E. (Eds.) (1985). *Activity Report: Automatic Control 1984-1985*. (Annual Reports TFRT-4014). Department of Automatic Control, Lund Institute of Technology (LTH).

Total number of authors:

2

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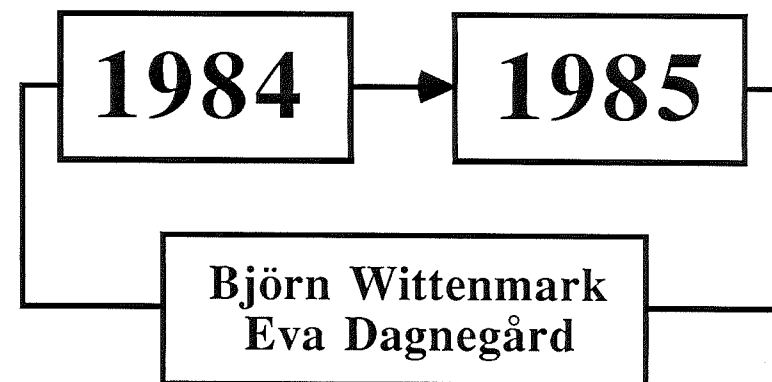
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ACTIVITY REPORT



ACTIVITY REPORT

1984–1985

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December 1985

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**Printed in Sweden
Reprocentralen
Lunds Universitet 1985**

Department of Automatic Control Lund Institute of Technology P.O. Box 118 S-221 00 Lund Sweden		Document name ANNUAL REPORT	
		Date of issue December 1985	
		Document Number CODEN: LUTFD2/(TFRT-4014)/1-36/(1985)	
Author(s) Björn Wittenmark Eva Dagnegård		Supervisor	
		Sponsoring organisation	
Title and subtitle Activity Report 1984–1985			
Abstract <p>The report surveys the activities during the academic year 1984–85 at the Department of Automatic Control, Lund Institute of Technology, Lund, Sweden. At the civilingenjör level (\approx MS) eight different courses are given on regular basis. Almost 600 students have participated during the year. Also sixteen MS-theses and one PhD-thesis have been completed.</p>			
Key words			
Classification system and/or index terms (if any)			
Supplementary bibliographical information			
ISSN and key title			ISBN
Language English	Number of pages 36	Recipient's notes	
Security classification			

The report may be ordered from the Department of Automatic Control or borrowed through the University Library 2, Box 1010, S-221 03 Lund, Sweden, Telex: 33248 lubbis lund.

Contents

1. Introduction	7
2. Education	8
3. Research	9
4. Reglermöte -85	16
Appendixes:	
A. List of personnel	17
B. Published papers and conference contributions	19
C. Reports	22
D. Courses and seminars at the department	26
E. Lectures by the staff	29
F. Travels	34

1. INTRODUCTION

This report covers the activities of the department in the academic year 1984/85.

A larger survey of the changes in courses at the department was presented in the activity report of the last year, Report TFRT-4013. This report gives a short summary of the research activities during 1984-85. In summary about 570 students have taken one or several of the eight courses that are given by the department.

The research has continued in established areas such as adaptive control and computer aided design. A new large project in Computer Aided Control Engineering (CACE) has started during the year. This project is further described in Section 3.

We want to thank our sponsors, The Swedish Board for Technical Development (STU), the Swedish Board for Energy Source Development (NE), The Swedish Water and Wastewater Works Association (VAV), and The Käppala Sewage Works, Lidingö, 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 taught as a part of the engineering curricula in Applied Physics (F), Electrical Engineering (E), Computer Engineering (D), Mechanical Engineering (M), and Chemical Engineering (K).

During the past year the following courses have been given at the department:

	<u>1984/85</u>
Automatic control, linear systems (F,E,D)	197
Automatic control, linear systems (M)	75
Automatic control for chemical engineers (K)	30
Process control (K)	96
Computer controlled systems (F,E,K)	55
Systems engineering (M)	16
Computers in control systems (F,E,M,K)	40
Applied real-time programming (F,E)	58

The figures gives the number of students that took the courses. One new course 'Process Control' has been developed during the year. This is a mandatory course for all chemical engineers. This course has replaced the two courses 'Automatic Control for Chemical Engineers' and 'Principles of Automatic Control'. The new course gives an introduction to automatic control with emphasis on chemical engineering applications. There are lectures (26 h), problem solving sessions (28 h) and laboratory work (16 h) in the course.

Eighteen students have completed their MS-dissertations in Automatic Control during the period. A list of the MS-theses is given in Appendix C. One PhD-thesis have been completed during the period.

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 parts, theory and applications. The main research areas have been

- Adaptive control
- Computer aided control engineering
- Expert control
- Control based on picture information; Visual servoing
- Control of waste water treatment systems
- Control of biotechnological processes

Adaptive Control

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

Adaptive control has been a vital part of the research efforts at the department for a long time. The results has been extremely successful in terms of papers and reports as well as in activities that have been started at universities and industries based on the ideas developed at the department.

Robustness problems

Stability is a fundamental issue for all control systems. Several stability theorems have been published for adaptive control systems. They are, however, severely limited because of the restricted assumptions made. One of the most restricted assumptions is that the model used in the adaptive has the same complexity as the system to be controlled. In practice the adaptive controllers are, however, based on comparatively simple models. Averaging techniques have been shown to be a promising method of dealing with the robustness problem. Analysis of a counterexample by Rohrs has successfully been done using this technique. Averaging methods are useful since they capture the fundamental aspect that adaptive systems have different time scales, one for the ordinary feedback and one for the parameter adjustment.

Autotuning

A new approach to automatic tuning of PID-controllers has been developed at the department. One version is commercially available in the NAF Autotuner. The approach has been further developed and different types of autotuners are now available. It is for instance possible to make autotuning to prescribed phase or amplitude margins or to place the dominant poles of the system. The auto-tuning algorithms are also of interest in a more general framework since they can be used to initialize other adaptive algorithms like the model reference algorithm or the self-tuning regulator.

Stability

Stability properties of deterministic direct adaptive controllers with least squares estimation have been investigated. The approach has been to use Lyapunov theory to show global stability and exponential convergence.

Adaptive friction compensation

The problem of torque friction compensation in direct current motors has been considered during the year. From physical laws it is possible to derive a nonlinear discrete time polynomial representation. A control design can be done for a linearized model combined with a nonlinear compensation. The compensation is adaptive and takes care of nonlinear effects and model parameter uncertainties.

Computer Aided Control Engineering (CACE)

(Sven Erik Mattsson, Jan Eric Larsson, Per Persson)

A new project in the computer aided control engineering area has been started. The project is supported by the Swedish Board for Technical Development, STU and is scheduled to run for five years with a total budget of 7.5 MSEK.

Computer aided control engineering (CACE) aims at developing efficient tools for modeling, analysis, simulation, design and implementation of control systems. During the two first years a number of pilot projects will be run to investigate the possibilities of the new hardware and software technology.

The new workstations with high performance, real-time graphics now appearing on the market open new possibilities to man-machine interaction. To investigate these possibilities a workstation IRIS 2400 from Silicon Graphics, has been purchased. It is a high performance engineering workstation with fast, interactive, color graphics in hardware. In one pilot project its possibilities are investigated by development of a prototype system, which is chosen to be a simulator for dynamical systems. The idea is to use hierarchical block diagrams to describe the decomposition of the model and the interconnection structure and to use continuous zooming to show internal details. The simulator will accept models described by ordinary differential equations and algebraic equations. The possibility to enter the model in the form of equations both facilitates and makes the modelling simpler and the documentation becomes better.

In another pilot project it is investigated how expert system methodology can be used to supply a CACE system with expert knowledge and how it can be used to adapt the interface to the user. The system under design is an expert system to support the use of IDPAC, which a package for data analysis and parameter estimation.

A CACE system has to perform a lot of calculations. Today these are performed numerically, but in the future it will be common to use packages for symbolic formula manipulation. There are many potential advantages of using symbolic formula manipulation. First, an analytic expression may reveal a relation better than a diagram or a table with numbers. Second, symbolic formula manipulation can be used to transform a problem to better conditioned problem before numeric solution. We will start a pilot project to investigate the possibilities to use numerics and symbolic formula manipulation for design of multivariable control systems on polynomial form.

An important conclusion from earlier project is that it is very fruitful to view a CACE system as a high level problem solving language. Design of such a language is an important task. A central point is how to represent and manipulate systems. A pilot project to investigate existing CACE package from this point of view will be started.

Expert Control

(Karl-Erik Årzén)

Process control is an area where expert systems have several natural applications at different levels. An expert system can be used for global alarm and performance analysis. At this level the expert system is typically used on top of an existing process control system. It is mainly used as a tool for the operator. The expert system gives information and advice to the operator.

In this project a rule based expert system is instead used as a part in the feedback loop of a controller. The expert system has the task to orchestrate the application of numerical algorithms for control, identification and supervision to the plant. The expert system should decide in which order the algorithms are applied and their parameter setting. The result of the application of one algorithm increases the amount of knowledge of the plant and affects the application of further algorithms. Knowledge of the controlled plant is successively built up during the operation of the system. The expert system approach makes it possible to include heuristics and rules of thumb of experienced process operators in the controller. The expert system is used in real time and in closed loop i.e. not only as an analysis tool for the operator. The goal is to improve the control at the single loop level.

A large part in existing controllers consists of a logic safety jacket to insure safe operation. This logic network grows when several different algorithms are used together. By implementing the network as rules in the expert system a natural division between logic and algorithms is achieved. The implications the expert system has on the user interface of the controller is described.

An environment for experiments has been implemented. The environment is implemented on a Vax 11/780 under VMS. The expert system is written in Franz Lisp under Eunice and the algorithms in Pascal. These two parts are implemented as VMS subprocesses that communicates by sending messages through mailboxes. The mailboxes are associated with text files. This makes it possible to send and evaluate Lisp functions as messages. A third process written in Lisp is used as user interface.

Experiments have been performed with this environment to test the basic ideas behind expert control. In these experiments the expert system was implemented in the forward chaining production system OPS4. The expert system waits for incoming messages when no rules are found that match the database. The incoming messages enter new elements in the database and the recognize-act cycle continues. The messages sent to the algorithms are either to start, stop or change parameters of an algorithm and the messages received are either results from an identification algorithm or an alarm from a supervision algorithm. The system was used in a Ziegler-Nichols auto-tuner for PID control that consisted of 4 algorithms and 70 rules.

Visual Servoing

(Lars Nielsen, Ola Dahl)

The goal of the project is to study pictures and sequences of pictures in connection with control systems. The main part has been devoted to theoretical and experimental studies of algorithms for detecting objects. A typical technical application is robots with vision. Experiments have been done in the laboratory. An experimental laboratory system has been built up where relevant features of visual servoing have been tested and demonstrated. Typical problems that have been investigated are changes in light and illumination and how to track the objects when they are moving in the picture.

The program includes such aspects as image processing, image interpretation, perspective corrections, feedback control along the path, route planning and obstacle avoidance.

Control of Wastewater Treatment Systems

(Gustaf Olsson, Lars Rundqwist, Ulf Holmberg, Craig Elevitch)

The activities have continued along the same lines as in the previous year. The project has received favourable international recognition during this year. Four papers were presented in at the IAWPRC (International Association on Water Pollution Research and Control) International Symposium on Instrumentation and

Control of Water and Wastewater Treatment and Transport Systems, held in April 1985 in Houston, Texas and Denver, Colorado, USA. Another two papers from the project were presented at international conferences.

Progress in the self-tuning control of the aerators at the Käppala Sewage works was reported in Olsson-Rundqwist-Eriksson-Hall (1985). The results have demonstrated process related problems in dissolved oxygen control. The problem to find relevant dissolved oxygen set-points has yet to be solved. This has initiated continued cooperation with the Institute for Surface Chemistry (Ytkemiska institutet). The control of all six aerators in parallel in Käppala has been delayed due to late deliveries of new equipment to the plant. This phase of the project will continue in early 1986.

Dynamic modelling of clarifiers has been reported in Olsson-Chapman (1985) and presented at the Water Pollution Control Federation Annual Meeting in New Orleans 1984. The cooperative effort with Environment Canada continues. A new pilot scale clarifier is being designed in Burlington, Ontario.

The hydraulic properties of wastewater treatment plants and its consequences for design and operation has been considered extensively. New results were published in Olsson-Stephenson (1984).

The estimation of oxygen uptake rate in biological wastewater treatment has been considered. Since the oxygen uptake rate has to be estimated simultaneously with the oxygen transfer rate the problem is far from trivial. New satisfactory results have been obtained and will be presented in Holmberg-Olsson (1985).

The work on a model library of biological wastewater treatment systems has continued. The interest for the library has grown considerably after the presentation in Houston, Olsson-Holmberg-Wikström (1985). In cooperation with the Swedish Water and Waste Water Works Association (VAV) experimental data from full scale plants have been made available and been evaluated, see Olsson-Reinius-Hultman (1985).

Control of Biotechnological Processes

(Per Hagander, Jan Peter Axelsson)

A cooperative effort has been established with the Division of Biotechnology, Chemical Center. A joint project on control in biotechnological processes has been funded by STU since 1983. Some work is going on with other divisions, mainly in terms of master thesis projects.

The purpose of the work is to investigate the possibilities for process control using direct measurements of substrate, product and intermediates in the processes. Work by several other groups in this field relies on in-direct measurements based on the contents of the gas phase of a reactor. Characteristic variables of the process are then derived from these measurements using various types of linear and non-linear filters.

Substantial work on biosensors is going on in Lund. One sensor system used in the project is based on immobilized enzymes and flow calorimetri. Another system is based on a silicone tubing together with a semiconductor gas sensor. With this method the ethanol concentration of a broth is available for control purpose.

The sensors have been applied to well-known processes based on yeast. Continuous production of ethanol from sugar has been studied, using immobilized cells in a stirred tank reactor and also in combination with a plug flow reactor. Control of the flow rate was based on substrate and product concentrations. Our current interest is focused on fed-batch production of baker's yeast. Here measurement of ethanol concentration gives a sensitive indication of the metabolic state of the cells. The main control difficulty is to track the exponential increase in substrate demand. Further, the process dynamics varies substantially, as the cultivation proceeds. A well tuned PID regulator gives reasonable performance but there are potentials for improvements.

Control strategies are tested in laboratory scale. A standard fermentor with a volume of 8 liters has been used. The fermentor is interfaced to a LSI 11/03 system for control and data aquisition.

4. Reglermöte -85

May 29-30, 1985, the department arranged a workshop in Automatic Control, 'Reglermöte -85', for Swedish industries and universities. This series of workshops has earlier taken place at different universities and industries in Sweden, but no workshops have been arranged for about ten years. Reglermöte -85 was a new attempt to bring together engineers and researcher from different areas and parts of Sweden. The workshop was arranged in cooperation between the IFAC National Committee, Instrumenttekniska Föreningen (ITF) and the department. About 100 persons participated and 18 papers were presented. Abstracts of the papers are found in the report TFRT-7283.

A. List of Personnel

Professor

Karl Johan Åström

University lecturers (Universitetslektorer)

Gustaf Olsson
Björn Wittenmark

Acting (part time) university lecturers

Rolf Johansson
Tore Hägglund

Docent

Per Hagander

Research associate (Forskarassistent)

Matz Lenells (part time)
Sven Erik Mattsson (part time)
Lars Nielsen (part time)

Research engineers (Forskningsingenjörer)

Leif Andersson
Rolf Braun
Tomas Schönthal (programmer)

Research assistants and Teaching assistants (Forskningsassistenter och Assistenter)

Jan Peter Axelsson (PhD candidate)
Craig Elevitch (BSc)
Hilding Elmqvist (PhD)
Ulf Holmberg (PhD candidate)
Tore Hägglund (PhD)
Rolf Johansson (PhD)
Jan Eric Larsson (PhD candidate)
Mats Lilja (PhD candidate)
Michael Lundh (PhD candidate)
Lars Malmheden (PhD candidate)
Sven Erik Mattsson (PhD)
Bengt Mårtensson (PhD candidate)
Lars Nielsen (PhD candidate)
Bernt Nilsson (PhD candidate)

- personnel -

Per Persson (PhD candidate)
Lars Rundqwist (PhD candidate)
Anders Wallenborg (PhD candidate)
Karl-Erik Årzén (PhD candidate)
Ann-Britt Östberg (MSc)

Visiting scientists (Gästforskare)

Konrad Braun, Div of Automatic Control, ETH, Zürich, Switzerland
(Jan 15 - May 31, 1985)

Carlos Canudas, Laboratoire d'Automatique de Grenoble, France.
(From Jan 14, 1985)

Technical drawings (Tekniskt biträde)

Britt-Marie Carlsson
Doris Nilsson

Secretaries (Sekreterare)

Eva Schildt
Agneta Tuszynski (part time)
Eva Dagnegård (part time)

B. Published Papers and Conference Contributions

- Andersson L, Hagander P, Hall G, Jahnberg S, Åström K J: Programkonstruktion med Ada - en tillämpningsstudie (Program design using Ada, an application study). Publication Mekanresultat 85006, Sveriges Mekanförbund 1985.
- Åström K J : Tekniköverföring från processindustrin. In Datormognad inom byggbranschen (Ove Engström, editor) (Technology transfer from the process industry. In "Computer Literacy in the Building Industry"), Byggeforskningsrådet, Report G23:1984, Statens råd för byggnadsforskning, Stockholm.
- Åström K J: Ziegler-Nichols auto-tuners. ISA Conference, Houston, Texas, Oct 22-25, 1984.
- Åström K J: Adaptive control - a way to deal with uncertainty. In "Lecture Notes in Control and Information Sciences" (M Thoma, editor), Proc DFVLR Int Seminar on Uncertainty and Control, Bonn, May 1985, Springer-Verlag, pp 131-152.
- Åström K J: Auto-tuning, adaption, and expert control. Proc American Control Conference, Boston, Massachusetts, June 19-21, 1985.
- Åström K J: Instability mechanisms in adaptive control. 7th Int Symp on Mathematical Theory of Networks and Systems (MTNS-85), Stockholm, Sweden, June 10-14, 1985.
- Åström K J, Anton J J: Expert control. Submitted to Automatica, Dec 1984.
- Åström K J, Hägglund T: Automatic tuning of simple regulators. IFAC 9th World Congress, Budapest, July, 1984.
- Åström K J, Hägglund T: A frequency domain approach to automatic tuning of simple feedback loops. 23rd IEEE Conf on Decision and Control, Las Vegas, Dec 1984.
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- Ljung L, Åström K J (Editors): Identification, Adaptive and Stochastic Control. (IFAC 9th Triennial World Congress, Budapest, Hungary, 1984). Pergamon Press, 1985.
- Mårtensson B: Adaptive stabilization of general multivariable, continuous- or discrete time systems. 7th Int Symp on Mathematical Theory of Networks and Systems (MTNS-85), Stockholm, Sweden, June 10-14, 1985.
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C. Reports

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Dissertations

TFRT-1026 Sven Erik Mattsson: Modelling and control of large horizontal axis wind power plants. Feb 1985.

Final Reports

TFRT-3174 Bengt Mårtensson: The order of any stabilizing regulator is sufficient a priori information for adaptive stabilization. April 1985.

- TFRT-3175 Tore Hägglund: NFS-STU workshop on adaptive control. April 1985.
- TFRT-3176 Karl Johan Åström: A Simnon tutorial. July 1985.

Activity Reports

- TFRT-4013 Gustaf Olsson, Eva Dagnegård: Activity report 1982-1984. Dec 1984.

Master Theses

- TFRT-5308 Björn Malmström: Dynamisk modellering och simulering av värmecentral med fjärrvärmenät-tillämpning Skurup (Dynamical modelling and simulation of a district heating plant and network in Skurup). July 1984.
- TFRT-5309 Ulf Steen: Simulering och reglering av ett system med en tre-fluids-värmeväxlare (Simulation and regulation of a system including a three-fluid heatexchanger). June 1984.
- TFRT-5310 Jan Eric Larsson: An expert system interface for Idpac. July 1984.
- TFRT-5311 Carl Almquist: Automatisk utvärdering av mätvärden från en hammarkvarnsprocess (Automatic evaluation of measurement values from a hammer mill process). Aug 1984.
- TFRT-5312 Peter Lerup: Ett grafiskt hjälpmedel för programutveckling i Ada (A graphical tool for program development in Ada). Sept 1984.
- TFRT-5313 Anders Jansson: Beräkning av regulatorparametrar med hjälp av i regulatorn inbyggd process modell (Computation of regulator parameters using gain scheduling). Sept 1984.
- TFRT-5314 Kenneth Nilsson: Strukturidentifiering av aktivslamprocessen (Structural identification of the Activated sludge process). Nov 1984.
- TFRT-5315 Ulf Persson: Reglering av system med variabel tidsfördröjning (Control of systems with timevarying timedelay). Nov 1984.
- TFRT-5316 Bernt Nilsson: Enzymatisk hydrolys av cellulosa i tvåfas-system (Enzymatic hydrolysis of cellulose in two-phase system). Dec 1984.
- TFRT-5317 Magnus Taube: Grafisk presentation och editering av matematiska uttryck och reläschema (Graphic Presentation and editing of mathematical expressions and ladder diagrams). Dec 1984.

- TFRT-5318 Ulf Holmberg: Simulering av aktivslamprocessers dynamik (Simulation of the dynamics of activated sludge systems). Febr 1984.
- TFRT-5319 Magnus Lundblad, Richard Svensson: Simulering av frekvenssyntes (Design and simulation of frequency synthesis). Dec 1984.
- TFRT-5320 Mårten Lindberg: Reglering av aktivslamprocessen vid AKO, Karlshamn. En förstudie (Control of an activated sludge process at AKO, Karlshamn. A feasibility studie). Jan 1985.
- TFRT-5321 Jonas Brånhult: Optimal "fed-batch"-odling av jäst (Optimal fed-batch growth of bakers yeast). May 1985.
- TFRT-5322 Ulf Adamsson: Infrysning av livsmedel - simulering av en industriell process (Freezing of foods - simulation of an industrial process). May 1985.
- TFRT-5323 Stefan Nilsson, Tor Sjödin: Autonom reglercentral (Stand alone controller). June 1985.

Reports of Master Theses

- TFRT-6015 Björn Wittenmark: Master theses in Automatic Control. Sept 1984.

Internal Reports

- TFRT-7273 Tore Hägglund, Karl Johan Åström: A new method for design of PID regulators. July 1984.
- TFRT-7274 Rolf Johansson: Estimation and direct adaptive control of delay-differential systems. Sept 1984.
- TFRT-7275 Sten Bergman, Per Persson: A PC system for data acquisition and recursive parameter estimation. May 1985.
- TFRT-7276 Ulf Hagberg: PC program i Ada (PC programs in Ada). Oct 1984.
- TFRT-7277 Per Hagander, Björn Wittenmark: ANPAC - Analysis and synthesis of continuous time systems. Nov 1984.
- TFRT-7278 Bengt Mårtensson: Pascal systems in Simnon. Dec 1984.
- TFRT-7279 Leif Andersson, Eva Dagnegård: TEVE. Dec 1984.
- TFRT-7280 Ulf Holmberg, Anders Wallenborg: Concentration dynamics of a time variable tank system. A SIMNON simulation. Dec 1984.

- TFRT-7281 Bengt Mårtensson: Multivariable linear systems in Simnon. Dec 1984.
- TFRT-7282 Karl Johan Åström, Tore Hägglund: Dominant pole design. April 1985.
- TFRT-7283 Björn Wittenmark: Reglermöte 1985. June 1985.
- TFRT-7284 Bengt Mårtensson: Adaptive stabilization of general multivariable, continuous- or discrete-time linear systems. June 1985.

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 mechanical engineers (Reglerteknik för M)
Automatic control for chemical engineers (Reglerteknik MK)
Process control (Processreglering)
Computer controlled systems (Digital reglering)
Systems engineering (Systemteknik)
Computers in control systems (Datorer i reglerteknik)
Applied real-time programming (Tillämpad realtidsprogrammering)

PhD Courses

The following courses have been given:

Linear systems, 8 p (Per Hagander)	fall 1984
Olinjära system och stabilitetsteori, 6 p (Matz Lenells)	spring 1985

Undergraduate 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

Survey of control theory	Sep	21-27, 1984
Adaptive control	Oct	23-25, 1984
Adaptive control	Jan	22-24, 1985
Survey of control theory	March	4-7, 1985
Digital Control	April	16-18, 1985

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.

Seminars

1984

- Aug 8 Per-Olof Gutman (Technion, Haifa, Israel): Horowitz robust design method in the SISO case.
- Aug 9 Per-Olof Gutman (Technion, Haifa, Israel): Admissible statesets for linear control systems with bounded states and control.
- Aug 24 Oded Yaniv (Weizman Institute, Israel): Horowitz design method in the multivariable case.
- Sept 7 Jan Sternby (Gambro, Lund): Konsistens för minsta kvadratskattning - ett Bayesianskt angreppssätt (Consistence of least squares estimators - A Bayesian approach).
- Sept 28 Stephen Woo (Imperial Oil and Norsk Esso): Advanced process control in refineries.
- Oct 5 Karl-Erik Årzén (Lund): Prolog.
- Nov 6 Mike Grimble (Univ of Strathclyde): LQG Selftuners.
- Nov 16 Bengt Mårtensson (Lund): Flervariabla system (Multivariable control systems). A course at MIT, spring 1984, by Michel Athans and Günter Stein.
- Nov 21 Bengt Mårtensson (Lund): Linjär system teori (Linear system theory). A course at Harvard University, spring 1984, by Chris Byrnes.
- Nov 27 Kousuke Kumaman (Kyoshu Univ): Some methods for fault detection of dynamical systems.
- Dec 18 Karl Johan Åström (Lund): Intryck från USA (Travels report from USA).

1985

- Jan 11 Bengt Mårtensson (Lund): The order of any stabilizing regulator is sufficient a priori information for adaptive control.
- Jan 28 - Feb 1 H Hanselmann (Univ of Paderborn, West-Germany): Implementation of fast digital control systems (7 seminars).
- March 11 Chris Byrnes (Arizona State Univ): Root loci, asymptotic expansions, and stability of adaptive control.
- March 19 Leif Andersson (Lund): TeX (An introduction to using TeX at the department).
- April 1-3 D Atherton (Univ of Sussex): Stability and limit cycles in nonlinear control systems (4 seminars).

1985

- April 9 Karl Johan Åström (Lund): Stability theory - A follow-up of Atherton's lectures.
- April 11 Karl Johan Åström (Lund) and Carlos Canudas (Grenoble) Adaptiv robotreglering (Control of partially known systems).
- April 11 Rolf Johansson (Lund): Prefiltering and choice of sample rate for identification part of adaptive control.
- April 15 Rolf Johansson (Lund): Stability of adaptive control with LS identifiering.
- April 29 Chris Byrnes (Arizona State Univ and KTH): Nonlinear controllability for systems with symmetries.
- May 3 Bengt Mårtensson (Lund): The order of any stabilizing regulator is sufficient a priori information for adaptive stabilization. Tekn lic seminar.
- May 14 M Karny (Praha): Adaptive control at Czechoslovakian Academy of Science.
- May 21 Karl Johan Åström (Lund): Robusthet, adaptivitet och CACE - intryck från en resa till Tyskland och England (Robustness adaptivity and CACE - Impressions from a trip to Germany and England).
- May 24 Lars Odén (ASEA): Presentation av ASEA:s centrala forsknings avdelning (Presentation of computer related research at ASEA).
- June 3 Jan Eric Larsson (Lund): Projekt 2000, datorschack (Project 2000, computer chess).
- June 5 Carlos Canudas (Grenoble): Identification of process parameters.
- June 11 Karl Johan Åström (Lund): The computer aided control engineering project.
- June 14 G Blankenship (Univ of Maryland): Design of nonlinear filters using real and artificial intelligence.
- June 17-19 Alan Laub (Univ of California, St Barbara): Computational methods in control theory (6 seminars).

E. Lectures by the Staff

1984

- July 5 Karl Johan Åström: Expert control. IFAC 9th World Congress, Budapest, Hungary.
- July 5 Karl Johan Åström: Applications of adaptive control. Round table discussion at IFAC 9th World Congress, Budapest, Hungary.
- July 5 Tore Hägglund: Adaptive control of systems subject to large parameter changes. IFAC 9th World Congress, Budapest, Hungary.
- July 6 Karl Johan Åström: Automatic tuning of simple regulators. IFAC 9th World Congress, Budapest, Hungary.
- July 9 Karl Johan Åström: Automatic tuning of simple regulators. NSF-STU workshop on Adaptive Control, Lund, Sweden.
- July 9 Gustaf Olsson, Lars Rundqvist: Self-tuning control of the dissolved oxygen concentration in activated sludge systems. NSF-STU workshop on Adaptive Control, Lund, Sweden.
- July 10 Tore Hägglund: Recursive estimation of slowly time-varying parameters. NSF-STU Workshop on Adaptive Control, Lund, Sweden.
- July 10 Rolf Johansson: Lyapunov functions, cost functions, and adaptive control. NSF-STU Workshop on Adaptive Control, Lund, Sweden.
- July 10 Björn Wittenmark: Self-tuning regulator with increased prediction horizon. NSF-STU Workshop on Adaptive Control, Lund, Sweden.
- July 11 Karl Johan Åström: Expert control. NSF-STU Workshop on Adaptive Control, Lund, Sweden.
- July 11 Karl Erik Årzén: Experiments with expert control. NSF-STU Workshop on Adaptive Control, Lund, Sweden.
- Aug 8 Gustaf Olsson: Interactive simulation and identification. Weyerhaeuser Company, Technical Centre, Tacoma, Washington.
- Aug 15 Gustaf Olsson: Experiences of self-tuning control of activated sludge systems. Wastewater Technology Centre, Environment Canada, Ontario.
- Aug 16 Gustaf Olsson: Evaluation of municipal wastewater treatment plant data. Wastewater Technology Centre, Environment Canada, Burlington, Ontario.

1984

- Aug 21 Tore Hägglund: Fel-detektering baserad på parameterskattning (Fault detection based on parameter estimation). ASEA-Relays, Västerås, Sweden.
- Aug 23 Karl Johan Åström: Application aspects of adaptive controls. University of California, Berkeley, California.
- Sep 25 Gustaf Olsson: The propagation of hydraulic disturbances and flow rate reconstruction in activated sludge plants. 2nd Florence Workshop on Modelling and Control of Biological Wastewater Treatment, Italy.
- Oct 2 Björn Wittenmark: Adaptiv reglering (Adaptive control). JAS Symposium, Lund, Sweden.
- Oct 4 Gustaf Olsson: Hydraulic Shocks and their impact on secondary settler performance. Water Pollution Control Federation, 57th Annual Conference, New Orleans, USA.
- Oct 18 Karl Johan Åström: Theory and applications of adaptive control. General Motors Research Laboratory, Warren, Michigan.
- Oct 19 Karl Johan Åström: Automatic tuning of simple feedback loops. Dept of Electrical and Computer Engineering, School of Engineering, Amherst, Massachusetts.
- Oct 22 Karl Johan Åström: Ziegler-Nichols auto-tuners. ISA Conference, Houston, Texas.
- Oct 24 Karl Johan Åström: Adaptive control. University of Houston, Texas.
- Nov 11 Karl Johan Åström: Axplock bland reglerteknikens ideer och apparater (Ideas and machines in automatic control). Kungliga Fysiografiska Sällskapet i Lund, Sweden.
- Nov 30 Tore Hägglund: Automatisk inställning av PID-regulatorer (Automatic tuning of PID controllers). ASEA, Västerås, Sweden.
- Dec 6 Gustaf Olsson: Datorer för reglering i processindustrin, några exempel (Computers for control in the process industry - Some examples). Svenska Kemiingenjörers Riksförening, SKR kongress, Lund, Sweden.
- Dec 12 Karl Johan Åström: A frequency domain method for automatic tuning of simple feedback loops. 23rd IEEE Conf on Control and Decision, Las Vegas, Nevada.
- Dec 14 Karl Johan Åström: Interaction between excitation on unmodeled dynamics in adaptive control. 23rd IEEE Conf on Control and Decision, Las Vegas, Nevada.
- Dec 14 Björn Wittenmark: Sampling of a system with a time delay. 23rd IEEE Conf on Decision and Control, Las Vegas, Nevada.

1984

Dec 18 Björn Wittenmark: Self-tuning regulators - An overview.
University of California, Santa Barbara, California.

1985

- Jan 9 Karl Johan Åström: Mathematical models of Schuler tuned system. Joint US-Scandinavian Symp on Scientific Computing and Mathematical Modelling, Stockholm, Sweden.
- March 6 Karl Johan Åström: Periodiska svängningar i relästyrda system (Periodic oscillations in relay systems). Dept of Mathematics, Lund Institute of Technology, Sweden.
- March 13 Karl Johan Åström: Högnivåspråk för problemlösning (High level problem solving languages). IVA möte om Software Engineering, Stockholm, Sweden.
- March 14 Per Hagander: An expert system interface for IDPAC. Paper by J E Larsson, K J Åström. 2nd IEEE Control Systems Society Symp on Computer-Aided Control System Design (CACSD), Santa Barbara, California.
- March 14 Sven Erik Mattsson: Uses of CACSD tools in analysis and design of controls for windmills. 2nd IEEE Control Systems Society Symp on Computer-Aided Control System Design (CACSD), Santa Barbara, California.
- March 18 Gustaf Olsson: Modellbyggnad, simulering, dataanalys och identifiering av reningsverksdynamik (Modeling, simulation, data analysis, and waste water plant dynamics). Stockholms Va-verk, Stockholm, Sweden.
- March 20 Bengt Mårtensson: The order of any stabilizing regulator is sufficient a priori information for adaptive stabilization. Division of Optimization and System Theory, Royal Institute of Technology, Stockholm, Sweden.
- March 21 Karl Johan Åström: Robust adaptive control. Massachusetts Institute of Technology, Cambridge, Massachusetts.
- March 23 Tore Hägglund: En ny feldetekteringsmetod för adaptiv reglering (A new fault detection procedure for adaptive control). The Technical University of Denmark.
- March 29 Gustaf Olsson: Ny reglerteknik i processindustrin. Diskussionsmöte IVA-STU, Produktions- och Processteknik, Teknisk-vetenskapliga utvecklingstendenser (New developments in control. Discussion day on new trends in process and production technology). Arranged by Swedish Board for Technical Development (STU) and IVA. Royal Swedish Academy of Engineering Sciences (IVA), Stockholm, Sweden.

1985

- April 16 Björn Wittenmark: Sampling av signaler och digital reglering (Sampling of signals and digital control). STF Course, Kungälv, Sweden.
- April 16 Björn Wittenmark: Adaptiv reglering (Adaptive control). STF Course, Kungälv, Sweden.
- April 23 Gustaf Olsson: Simulation and identification. Weyerhaeuser Technical Centre, Tacoma, Washington, USA.
- April 25 Gustaf Olsson: Adaptive control, a short overview. Weyerhaeuser Technical Centre, Tacoma, Washington, USA.
- April 30 Gustaf Olsson: A model library for dynamic simulation of activated sludge systems. 4th IAWPRC Workshop on Instrumentation and Control of Water and Wastewater Treatment and Transport Systems, Houston, Texas.
- May 2 Gustaf Olsson: Modelling the dynamics of clarifier behaviour in activated sludge systems. 4th IAWPRC Workshop on Instrumentation and Control of Water and Wastewater Treatment and Transport Systems, Houston, Texas.
- May 2 Gustaf Olsson: Evaluation of wastewater treatment plant operational data by a common data base system. 4th IAWPRC Workshop on Instrumentation and Control of Water and Wastewater Treatment and Transport Systems, Houston, Texas.
- May 3 Gustaf Olsson: Dynamics and control of wastewater treatment systems. Final address presented at the 4th IAWPRC Workshop on Instrumentation and Control of Water and Wastewater Treatment and Transport Systems, Denver, Colorado.
- May 6 Karl Johan Åström: Automatic tuning of regulators. DFVLR - Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.V., Oberpfaffenhofen, Germany.
- May 3 Lars Rundqwist: Self-tuning control of the dissolved oxygen concentration in activated sludge systems. 4th IAWPRC Workshop on Instrumentation and Control of Water and Wastewater Treatment and Transport Systems, Denver, Colorado.
- May 7 Karl Johan Åström: Adaptive control - A way to deal with uncertainty. DFVLR Int Seminar on Uncertainty and Control, Bonn, Germany.
- May 15 Karl Johan Åström: The new CACSD project at Lund institute of technology. Colloquium on New Developments and Applications of CAD Packages to Control System Design. IEE, London.
- June 10 Karl Johan Åström: Instability mechanisms in adaptive control. 7th Int Symp on Mathematical Theory of Networks and Systems (MTNS-85), Stockholm, Sweden.

1985

- June 10 Rolf Johansson: Stability of direct adaptive control with LS-identification. 7th Int Symp on Mathematical Theory of Networks and Systems (MTNS-85), Stockholm, Sweden.
- June 10 Bengt Mårtensson: Adaptive stabilization of general multivariable continuous- or discrete time systems. 7th Int Symp on Mathematical Theory of Networks and Systems (MTNS-85), Stockholm, Sweden.
- June 21 Ann-Britt Östberg: A modern teaching laboratory for process control. American Control Conference, Boston, Massachusetts.
- June 21 Karl Johan Åström: Auto-tuning, adaptation, and expert control. American Control Conference, Boston, Massachusetts.

F. Travels

Karl Johan Åström participated in the 9th IFAC World Congress in Budapest in July, 1984. At that meeting he was responsible for the subsection on Adaptive Control. He presented two papers and he received a best paper award for his Automatica paper 'Theory and Applications of Adaptive Control'. In August he visited USA to prepare for the new CACE project. This included visits to UC Berkeley, LLNL, UCSB, Stanford, Xerox Parc, Reasoning Systems and others. In October he visited the ISA meeting in Houston to present an invited paper on auto-tuning. In connection with that trip he also visited the General Motors Research Laboratories and University of Massachusetts. In December he participated in the 23rd CDC where he presented two papers. He also visited UCB, Stanford, Xerox Parc, Reasoning Systems, and IBM Research.

In March, 1985, Åström visited Massachusetts Institute of Technology. During the same trip he also visited LMI and Symbolics to discuss hardware for the CACE project and Leeds and Northrup to discuss adaptive control. In May he visited Germany to participate in a DFVLR meeting on Uncertainty. He also visited England to discuss the English CACE projects with their steering committee. In connection with that he also presented a paper at an IEE meeting on adaptive control. In June he visited Stockholm to present a paper at the MTNS-85 and he visited Boston to participate in the American Control Conference, where he had five papers.

Jan Peter Axelsson visited Germany and Schweiz in August 1984. He participated in the 3rd European Congress of Biotechnology in Munich, 10-14 September 1984, and present a poster. After the conference he was invited to visit dr Sonnleitner, prof Fiechter's department at ETH, Zurich. He also had the opportunity to talk with dr Käppeli at the department. Together with Carl Fredrik Mandenius the lab was shown and they were also introduced to dr Adler chem. eng. and he showed his lab.

Per Hagander participated in the 3rd European Congress on Biotechnology in Munich, FRG, 10-14 September 1984. He also participated in CACSD-85 at St. Barbara, 13-15 March, 1985.

Tore Hägglund visited Hungary in July 1984, where he participated in IFAC 9th World Congress and presented a paper.

Sven Erik Mattsson visited USA for five weeks in July to August 1984. He participated together with Hilding Elmqvist in SIGGRAPH'84, July 23-27, 1984, in Minneapolis. The following week they went to the San Francisco area and visited Stanford University, Stanford Silicon Graphics Inc, Mountain View and Sun Microsystems Inc, Mountain View. Mattsson then then visited professor Polak's group, University of California, Berkeley, and worked with their CAD package DELIGHT.

Mattsson also visited USA for three weeks in March 1985. He participated in CACSD'85 the 2nd IEEE Control Systems Society Symposium on Computer-Aided Control System Design, Santa Barbara, California, March 13-15, 1985, and presented a paper. The second week he went to the San Francisco area together with Sten Bergman, ASEA Relays. They visited Stanford University, Stanford Silicon Graphics Inc, Mountain View, Fairchild in Palo Alto, Xerox in Palo Alto, Systems Control Inc, in Palo Alto, and other companies in Silicon Valley. The third week they went to Boston and visited MIT, LISP Machine Inc, and Symbolics Inc.

Gustaf Olsson made a two week tour to USA and Canada during August 1984 to follow up cooperative research projects at Environment Canada in Burlington, Ontario, and Weyerhaeuser Company, Tacoma, Washington. He presented a paper in Florence in September at a workshop on Biological Modelling and continued to the USA to present a paper at the Water Pollution Control Federation 57th Annual Meeting in New Orleans. He also participated in the program committee work for the IAWPRC 4th International Workshop, to be held in Houston, April 1985.

From April 21 to May 5 he visited USA for a combined research and conference tour. He visited Weyerhaeuser Technical Centre in Tacoma, Washington, and participated and lectured at the IAWPRC 4th International Workshop on Instrumentation and Control in Houston and Denver.

Lars Rundqwist visited USA from April 27 to May 10 1985. He participated and lectured at the IAWPRC 4th workshop on Instrumentation and Control in Houston and Denver. He further visited Honeywell Inc, Minneapolis, Minnesota; General Electric Co, Schenectady, New York; MIT, Cambridge, Massachusetts and Foxboro Co, Foxborough, Massachusetts.

Tomas Schönthal visited the USA during the spring 1985. He attended the CACSD'85 symposium in Santa Barbara, CA (March 13-15). The following six weeks he spent with Alan Laub's group at University of California, Santa Barbara, integrating their state-of-the-art numerical algorithms with our own design package Synpac. Finally he visited John Little at The MathWorks, Portola Valley, CA for three weeks, sharing their experiences in developing engineering software for personal computers.

Björn Wittenmark participated in the 9th IFAC World Congress in Budapest, July 1984. In December he visited USA and participated at the 23rd CDC in Las Vegas and presented a paper. He also visited and lectured at the Chemical Engineering Department of University of California in Santa Barbara.

Ann-Britt Östberg visited USA in June 1985. She participated in the conference on Applied Motion Control, June 11-13, in Minneapolis. During the week in Minneapolis she also visited Electrocraft Corporation. The following week she went to Boston and participated in American Control Conference, June 19-21, where she presented a paper. She then went to California where she visited Reasoning Systems Inc, in Palo Alto, Stanford University and Berkeley University.