Activity report: Automatic Control 1977-1978 and 1978-1979

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ACTIVITY REPORT 1977-78 1978-79

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Department of Automatic Control | Lund Institute of Technology

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ACTIVITY REPORT

1977-1978 and 1978-1979

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Activity Report 1977-1978 and 1978-1979

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Abstract

The report surveys the activities at the Department of Automatic Control, Lund Institute of Technology, during the academic years 77/78 and 78/79. During these two years 25 master theses and 7 PhD theses were completed.

The major areas of research have been system identification, adaptive control and computer aided design of control systems. The applied research was devoted to adaptive ship steering, control of waste water treatment plants, control of heating and ventilation systems, and biomedical control problems.

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TABLE OF CONTENTS

1. INTRODUCTION

In this report the activities over the academic years 77/78 and 78/79 are reported. The research projects are briefly described and the main results and contributions are summarized. Reports listed in the appendices give further details. Only a limited number of copies of the reports are available through the Department. It is, however, possible to borrow the reports through the University Library in Lund. Its address is:

University Library 2
Box 1010
S-221 03 LUND Sweden

One main task has been to bring out the results of our research to industry. We see a a growing interest for the interactive programs SIMNON and IDPAC. These programs are now available at about 10 computer centres. The programs are used by many engineers as a standard tool for analysis and synthesis of control systems. There is also a growing interest in applications of adaptive control. The self-tuning regulators with their simplicity and good performance will probably be used quite frequently in the future.

We want to thank our sponsors, The Swedish Board of Technical Development (STU), The Swedish Insitute of Applied Mathematics (ITM), The National Board of Building Research (BFR), and the Swedish Water and Waste Water Works Association (VAV) for their support to our projects.

2. RESEARCH

The major research areas are:

Stochastic control theory
Computer aided design
Biological and medical systems
Applications

Stochastic control theory

Within this project we have been working with system identification and adaptive control. The research in system identification is now mainly done within application projects. The techniques and programs for identification have been used for modelling of for instance ships, waste water treatment plants, heating and ventilation systems, fluidized bed combusters, boiling water nuclear reactor, and extruder.

In order to bring out the knowledge about the identification program IDPAC, two courses were held during Spring 1979. About 35 persons from different industries participated and got on hands experience of the program. The material for the course have also been used by The Swedish Forest Products Research Laboratory (STFI).

The adaptice control project has continued with research on different types of self-tuning controllers. Self--tuning controllers based on pole-placement for servo applications have been developed. There are many different combinations of estimators and control design methods that can be used in order to get a self-tuning controller. To make it easier to investigate different combinations an interactive program based on SIMNON has been implemented.

The stability problem of adaptive control is of fundamental importance both in practice and theory. Some stability results on self-tuning regulators have been obtained. It can be shown that under reasonable assumptions the closed loop signals will be bounded if the disturbance is bounded.

Work has also been done leading to a unification of self-tuning regulators and model reference adaptive controllers. It is for instance shown that model reference adaptive controllers can be derived using the self--tuning approach. The augmented error in model reference adaptive controllers can be given a new interpretation and the nature of the often used positive real condition can be explained.

Another area of adaptive control that has been investigated is extremal control. There are many control problems that can be formulated as extremal control problems. Many different model structures and problem formulations have been suggested in the literature. A survey of different methods has been done and further research has been initiated.

Computer aided design

The interactive programs for computer aided design of control systems have recieved a lot of attention. The philosophy behind the interactive programs has been brought out through courses, papers and seminars. The programs are now available at many different places. The main work during the reported period has been devoted to structuring of the programs.

The programs are now easy to implement on different computers. The installation dependent routines are brought to a minimum and implementation guides are developed. All basic interaction is grouped into a package called INTRAC, which now is the basis for all our interactive software. INTRAC can also be used separately to make a set of FORTRAN routines interactive.

The following programs are now available at the department:

IDPAC	signal analysis and system identification
SIMNON	simulation of nonlinear differential and difference equations
SYNPAC	synthesis of linear quadratic controllers and simulation
MODPAC	analysis and transformation of linear systems

The programs are used in most of the other research activities at the department.

Biological and medical systems

The work on macromolecular transport has ended with a PhD thesis in Physiology at Uppsala University. It was demonstrated how dynamical experiments enables an investigation of mixed transport processes.

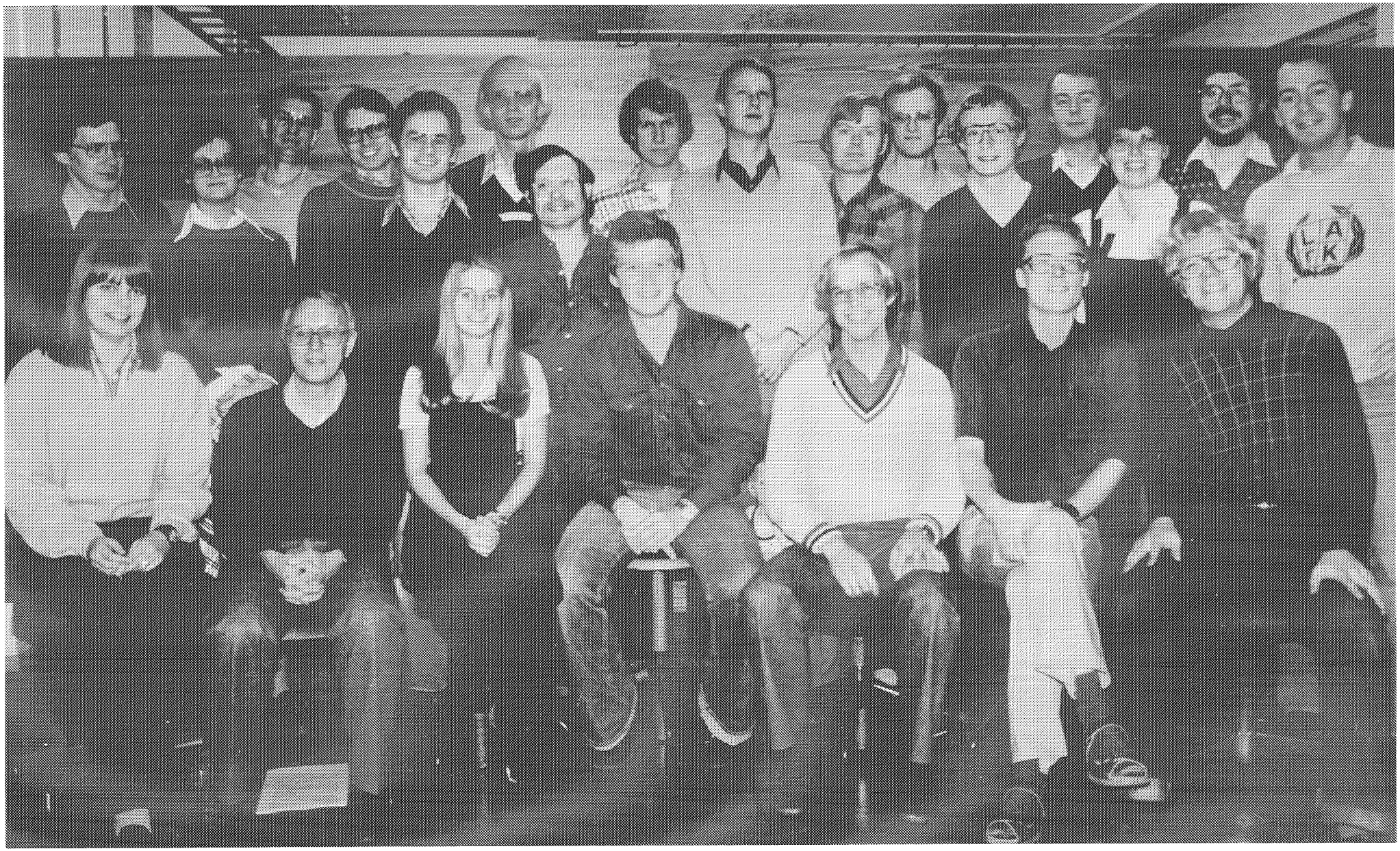
3. TRAVELS

Travels by the staff are listed in Appendix F.

During May 26-28, 1979, about 20 members of the department made a tour to different industries in the western part of Sweden. The following companies were visited:

Volvo, Göteborg (Automobiles)
LM Ericsson, Mölndal (Military electronics)
BP Raffinaderi, Göteborg (Crude oil refining)
Gruvöns Bruk, Grums (Paper and pulp)
Kamyr AB, Karlstad (Continuous digesters for pulp)
Uddeholms AB, Skoghall (Paper and pulp)
Volvo Flygmotor, Trollhättan (Jet engines)
Bofors AB, Bofors (Military equipment)
Bäckhammars Bruk, Bäckhammar (Paper and pulp)

The purposes of the travel were to experience how automatic control is applied in practice and to find out if our education fills the need of the industries. All participants felt that the travel gave much experience and we want to thank the companies for their hospitality.



APPENDIX A - LIST OF PERSONNEL

Professor

Karl Johan Åström

University lecturers (Universitetslektorer)

Gustaf Olsson
Björn Wittenmark (in USA 77-78)
Jan Holst (acting 77-78)

Research assistant (Forskarassistent)

Per Hagander (PhD)

Research engineers (Forskningsingenjörer)

Leif Andersson
Bo Egardt (PhD 1978)
Hilding Elmqvist (PhD 1978; in USA 78-79)
Tommy Essebo (programmer)
Ivar Gustavsson (PhD)
Lars Jensen (PhD 1978)
Claes Källström (PhD 1979)
Ann-Britt Nilsson (programmer)
Lars Pernebo (PhD 1978; in USA 78-79)
Tomas Schönthal (programmer)
Jan Sternby (PhD)
Johan Wieslander (PhD 1979)

Teaching assistants (Assistenter)

Per-Olof Gutman (PhD candidate; in USA 77-78)
Tore Hägglund (PhD candidate)
Matz Lenells (PhD candidate)
Carl Fredrik Mannerfelt (PhD candidate)
Sven Erik Mattsson (PhD candidate)
Per Molander (PhD candidate)

Laboratory engineer (Laboratorieingenjör)

Rolf Braun

Visiting scientists (Gästforskare)

Prof Rod Bell (Sep 78 - May 79)
MacQuarie University, Australia

Prof Alan Foss (May - June 78)
University of California, Berkeley, USA

Dr Toni Havlichek (April - June 78)
Czechoslovak Academy of Science, Prague, Czechoslovakia

Dr David Hill (Sep - Dec 78)
University of Melbourne, Australia

Dr Mogens Levin (Sep - Dec 77)
DTH, Lyngby, Denmark

Prof Lou Westphal (Sep - Dec 78)
University of Queensland, Australia

Technical drawings (Tekniskt biträde)

Britt-Marie Carlsson

Secretaries (Sekreterare)

Eva Schildt
Eva Dagnegård (half time)
Lilian Andersson (part time)

Typist (Skrivhjälp)

Kerstin Ulveland

APPENDIX B - PUBLISHED PAPERS AND CONFERENCE CONTRIBUTIONS

Åström K J: Piece-wise deterministic signals. Symposium on Systems Optimization and Analysis, IRIA, Paris, France, Dec 1978.

Åström K J: Stochastic control problems. Mathematical Control Theory, Proc, Canberra, Australia 1977. Editor W A Coppel, Springer-Verlag, Heidelberg 1978.

Åström K J: Algebraic system theory as a tool for regulator design. Acta Polytechnica Scandinavia, Ma 31, Topics in System Theory. Publication in honour of Prof Hans Blomberg on the occation of his sixtieth birthday on December 18th, 1979.

Bergman S, Gustavsson I: Identification of global noise in a boiling water reactor by means of spectral and parametric methods. J Nuclear Science and Technology 16 (1979) 77-88.

Egardt B, Molander P: Multivariable root-loci for positive real transfer matrices. Int J Control 28 (1978) 253-259.

Egardt B: Unification of some continuous-time adaptive control schemes. IEEE Trans Automatic Control AC-24 (1979) 588-592.

Egardt B: Stability of Adaptive Controllers. Springer-Verlag, Berlin Heidelberg, 1979.

Gillblad T, Olsson G: Computer control of a medium sized activated sludge plant. Prog Wat Tech 9 Nos 5/6 (1977) 427-433.

Gutman P O, DiStefano J J: Parameters of thyronine metabolism from normal and pathological human data: Some numerical results concerning parameter estimates, their variability and their possible utility in diagnostic classification. Report UCLS-ENG-7730, Univ of California, Los Angeles, April 1977.

Hagander P: Modeling and insulin-glucose control. VIIe Colloque International du College de France sur le Thême: L'Idée de Régulation dans le Mouvement des Sciences, Dec 5-10, 1977.

Hagander P, Tranberg K-G, Thorell J, DiStefano J J: Models for the insulin response to intravenous glucose. Mathematical Biosciences 42 (1978) 15-30.

Hamza M H, Tödtli J, Wittenmark B: Prediction of natural gas disposition. Symposium on Simulation, Modelling and Decision in Energy Systems, Montreal, June 1-2, 1978.

Källström G, Åström K J, Thorell N E, Eriksson J, Sten L: Adaptive autopilots for large tankers. IFAC World Congress, Helsinki, June 12-16, 1978, pp 477-484. Also in Automatica 15 (1979) 241-254.

Källström C G, Byström L: System identification of linear and nonlinear ship steering dynamics. 5th Ship Control Systems Symposium, Annapolis, Maryland, USA, 1978.

Lee K G, Wittenmark B, Kleinmann D L: Identification of parameters in the optimal control model. 14th Annual Conference on Manual Control, Los Angeles, April 25-27, 1978.

Norrbin N H, Byström L, Åström K J, Källström C G: Further studies of parameter identification of linear and nonlinear ship steering dynamics. Report 1920-6, Swedish State Shipbuilding Experimental Tank, Gothenburg, Sweden, Sep 1977.

Olsson G: Automatic control in combined wastewater treatment plants. Invited paper, Int Environmental Colloquium, Liége, Belgium, May 1978.

Olsson G, Andrews J: Estimation and control of biological activity in the activated sludge process using dissolved oxygen measurements. IFAC Symp on Environmental Systems Planning, Design and Control, Kyoto, Japan, Aug 1977.

Olsson G, Andrews J: The dissolved oxygen profile - a valuable tool for control of the activated sludge process. Water Research 12 (1978) 985-1004.

Olsson G: Swedish experiences in instrumentation and control of wastewater treatment plants. Institut Recherche Chimie Applique, Paris, Dec 1978.

Olsson G: Process control in wastewater treatment plants - a survey (in Swedish). Swedish Association for water and wastewater works, M26, pp 13-72, April 1979.

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Pernebo L, Sternby J: Simulation of two suboptimal dual controllers. Int J Control 28 (1978) 545-556.

Pernebo L: An algebraic theory for design of controllers for linear multivariable systems, Part 1 - Structure matrices and feedforward design. Univ of Southern California, Los Angeles, California, May 1979.

Pernebo L: An algebraic theory for design of controllers for linear multivariable systems, Part 2 - Feedback realizations and feedback design. Univ of Southern California, Los Angeles, California, May 1979.

Rao P K, Wittenmark B: Suboptimal minimum energy controllers for process control. Symposium on Simulation, Modelling and Decision in Energy Systems, Montreal, June 1-2, 1978.

Rutili G, Hagander P: Transport of macromolecules in subcutaneous tissue. In G Rutili: Transport of Macromolecules in Subcutaneous Tissue Studied by FITC-Dextran. Acta Universitas Uppsaliensis, Abstracts of Uppsala Dissertations from the Faculty of Medicine 306, Uppsala, 1978.

Silverman L M, Pernebo L: Balansed systems and model reduction. Optimization Days, McGill University, Montreal, Canada, May 1979.

Sternby J: A regulator for time-varying stochastic systems. Paper 46B.4, IFAC World Congress, Helsinki, June 12-16, 1978.

Sternby J: Comments on 'Convergence of least squares identification algorithms applied to unstable stochastic processes'. Int J Systems Sci 9 (1978) 837-838.

Söderström T, Ljung L, Gustavsson I: A theoretical analysis of recursive identification methods. Automatica 14 (1978) 231-244.

Wittenmark B: Self-tuning algorithms for control, prediction and smoothing. Invited paper, Institute of Mathematical Statistics Meeting on Time Series Analysis, Ames, May 1-3, 1978.

Wittenmark B: A two-level estimator for time-varying parameters. Automatica 15 (1979) 85-89.

Wittenmark B, Rao P K: Comments on 'Single step versus multistep performance criteria for steady state SISO systems'. IEEE Trans Automatic Control AC-24 (1979) 140-141.

APPENDIX C - REPORTS

- Any of the listed publications may be borrowed through your library service or from the University Library in Lund:

  UB2
  Box 1010
  S-221 03 Lund, Sweden

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

  Department of Automatic Control
  Lund Institute of Technology
  Box 725
  S-220 07 Lund 7, Sweden

- There is a copying and handling charge of between $6.00 and $25.00 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-1013 Holst J: Adaptive prediction and recursive estimation. Sep 1977.

TFRT-1014 Jensen L: Digital reglering av klimatprocesser (Digital control of climate processes). May 1978.

TFRT-1015 Elmqvist H: A structured model language for large continuous systems. May 1978.

TFRT-1016 Pernebo L: Algebraic control theory for linear multivariable systems. May 1978.

TFRT-1017 Egardt B: Stability of model reference adaptive and self-tuning regulators. Dec 1978.

TFRT-1018 Källström C G: Identification and adaptive control applied to ship steering. May 1979.

TFRT-1019 Wieslander J: Interaction in computer aided analysis and design of control systems. May 1979.

FINAL REPORTS

TFRT-3147 Åström K J: Stochastic control problems. Nov 1977.

TFRT-3148 Åström K J, Westerberg B, Wittenmark B: Self-tuning controllers based on pole--placement design. May 1978.

TFRT-3149 Wieslander J, Elmqvist H: INTRAC. A Communication module for interactive programs. Language manual. Aug 1978.

TFRT-3150 Åström K J, Gustavsson I: Analysis of a self-tuning regulator in a servoloop. Oct 1978.

TFRT-3151 Åström K J: Self-tuning control of a fixed bed chemical reactor system. Nov 1978.

TFRT-3152 Åström K J, Gustavsson I: Reglering under osäkerhet (Stochastic control). Dec 1978.

TFRT-3153 Åström K J: Robustness of a design method based on assignment of poles and zeros. May 1979.

ACTIVITY REPORTS

TFRT-4009 Åström K J, Olsson G: Activity report 1976--1977. May 1978.

MASTER THESES

TFRT-5197 Gestrelius S: Hodkin-Huxley modellen anpassad till lågfrekventa nervimpulser (The Hodgkin-Huxley model applied to low frequency repetetive firing nerves). Aug 1977.

TFRT-5198 Westerberg B: Självinställande regulator baserad på polplacering (A self-tuning regulator based on pole-placement). Aug 1977.

TFRT-5199 Nordström H, Svensson L: Mätning, modellbygge, simulering och reglering tillämpat på en anläggning med värmepump (Measuring, modelling, simulation, and control of a heat-pump). Sep 1977.

TFRT-5200 Holmqvist B, Larsson L-E: Laboratorieprocess för flödessystem (Laboratory process for flow systems). Aug 1977.

TFRT-5201 Persson C: Generell assembler i STAGE 2 (General assembler in STAGE 2). Oct 1977.

TFRT-5202 Pålsson T, Rading L: Program för loggning och dataanalys på PDP11/03 (Program for logging and data analysis on PDP11/03). Nov 1977.

TFRT-5203 Karlström H: Minidatorsystem för styrning av hängtransportöranläggning (A computer system for mailbag sorting). Dec 1977.

TFRT-5204 Vonheim T: Mikrodatorreglering av en tunnelugn (Microcomputer control of a tunneloven). Dec 1977.

TFRT-5205 Apelblat J, Rydström P: Frånluftstemperaturreglering av flerfamiljshus (Return air temperature control of an apartment house). Dec 1977.

TFRT-5206 Andersson J, Melin J: Bestämning av parametrar i dynamisk modell för insulinsvar på glykoslast (Quantification of parameters of a dynamic model for insulin response to glucose load). January 1978.

TFRT-5207 Larsson C, Lindgren H: Program för frekvensanalys på PDP11/03 (Program for frequency analysis on PDP11/03). May 1978.

TFRT-5208 Lindgren S: Decentraliserad reglering av stora system med självinställande regulatorer (Decentralized control of large-scale systems using self-tuning regulators). May 1978.

TFRT-5209 Hägglund T: Reglering av yoghurttillverkning (Control of youghurt manufacturing). May 1978.

TFRT-5210 Hallström L-G: Generella beräkning på mätdata (Interactive program for computations on data files). June 1978.

TFRT-5211 Nilsson B, Tillberg K: Analys av reglersystemet till en cigarettmaskin (Analysis of the control system for a cigarette machine). June 1978.

TFRT-5212 Josefson G: Dynamiska modeller för belastning på ett kraftsystem (Dynamic models for the load on a power system). June 1978.

TFRT-5213 Blom A, Tengvall F: Digital reglering av brännportal (Digital control of a cutting machine). July 1978.

TFRT-5214 Norén P: Mikrodatorbaserat positioneringssystem för ASEA IRb-system (Microcomputer based positioning system for ASEA IRb-system). Oct 1978.

TFRT-5215 Olesen J, Jensen C: Identifiering av strängspruta (Identification of extruder dynamics). Oct 1978.

TFRT-5216 Wiberg S: Analys av extruder (Analysis of an extruder). Oct 1978.

TFRT-5217 Hultqvist G: Datastyrd svetsautomat - hårdvara (Computer controller welding machine - hardware). Nov 1978.

TFRT-5218 Upadhyaya L: Glykos insulin reglering (Glycose and insulin regulation). Dec 1978.

TFRT-5219 Löfgren L: Minidatorreglerad smältmaterialhantering (Minicomputer control of the mixing of materials of a melting plant). Dec 1978.

TFRT-5220 Johansson G, Jonasson K: Simulering av ämnestemperaturer i en stegbalksugn (Simulation of slab temperatures in a walking beam furnace). March 1979.

TFRT-5221 Ahlström A: Mätningar och experiment på laboratorieprocesser (Measurements and experiments on laboratory processes). May 1979.

REPORTS OF MASTER THESES

TFRT-6008 Holst J: Master theses in Automatic Control 76/77. Feb 1978.

TFRT-6009 Wittenmark B: Master theses in Automatic Control 77/78. March 1979.

INTERNAL REPORTS

TFRT-7121 Razevig V D: Digital simulation of continuous stochastic systems. May 1977.

TFRT-7122 Molander P: Stability of feedback systems with relays or saturations. Aug 1977.

TFRT-7123 Mannerfelt C F: Ett exempel på numeriska svårigheter vid beräkning av nollställen (An example of numerical problems associated with the computation of system zeros). Oct 1977.

TFRT-7124 Hagander P: Simulation programs for the Grodsky insulin-glucose model. Nov 1977.

TFRT-7125 Jensen L: Energibesparing vid entalpistyrning (Energy reduction with enthalpy control). Nov 1977.

TFRT-7126 Jensen L: Självinställande startoptimering (Self-adjusting start optimization). Nov 1977.

TFRT-7127 Apelblat J, Jensen L, Rydström P: Frånluftstemperaturreglering av flerfamiljshus (Control of return air temperature in apartment buildings). Nov 1977.

TFRT-7128 Schönthal T: INTRAC - Programmer's guide. Oct 1977.

TFRT-7129 Källström C G: Identification of the linear steering dynamics of the Sea Splendour. Dec 1977.

TFRT-7130 Källström C G: Determination of linear and nonlinear steering models for the USS Compass Island. Dec 1977.

TFRT-7131 Källström C G: Identification of the steering dynamics of the Sea Scout. Dec 1977.

TFRT-7132 Elmqvist H: A new model language for continuous systems. Dec 1977.

TFRT-7133 Bengtsson G, Egardt B: Internal properties and insensitive implementations of the Otto Smith regulator. Jan 1978.

TFRT-7134 Egardt B: A unified approach to model reference adaptive systems and self-tuning regulators. Jan 1978.

TFRT-7135 Åström K J, Olsson G, Wittenmark B, Holst J: Kursplanerevisioner i reglerteknik (Revisions of undergraduate courses in Automatic Control). Feb 1978

TFRT-7136 Olsson G: Instrumentation and control of wastewater treatment plants in the USA. March 1978.

TFRT-7137 Gillblad T, Olsson G: Implementation problems for activated sludge controllers. March 1978.

TFRT-7138 Ahlström A, Bergström J, Hallström L G, Hägglund T, Johansson B, Knorring O von, Larsson B, Lindsten L G, Pettersson H Å, Skoglund T, Tyren C, Vollmer L: Reglering av nivå och temperatur (Level and temperature control). March 1978.

TFRT-7139 Schönthal T: MODPAC V3A - Command guide. March 1978.

TFRT-7140 Egardt B: Unification of some adaptive control schemes - Part I: Continuous time. June 1978.

TFRT-7141 Olsson G: Automatic control in combined wastewater treatment plants. Invited paper, Int Environmental Coll, Liége, May 16-19, 1978. May 1978.

TFRT-7142 Sternby J: Analysis of an extremal controller for Hammerstein models. June 1978.

TFRT-7143 Sternby J: Turn-off reduction for the cautious regulator - a simulation study. June 1978.

TFRT-7144 Sternby J: Certainty equivalence and an identification problem from econometry. June 1978.

TFRT-7145 Sternby J: Performance limits in adaptive control. June 1978.

TFRT-7146 Holst J: Adaptive short-term prediction of power load. Load data. Aug 1978.

TFRT-7147 Källström C G: Lispid - User's manual. Aug 1978.

TFRT-7148 Elmqvist H: Simnon - An interactive simulation program - Implementation. Aug 1978.

TFRT-7149 Gustavsson I: User's guide for a program package for simulation of self-tuning regulators. Aug 1978.

TFRT-7150 Mattsson S E: Evaluation of a subroutine for Nelder and Mead search. Sep 1978.

TFRT-7151 Gillblad T, Olsson G: Styrning av avloppsreningsverk (Control of wastewater treatment works). May 1978.

TFRT-7152 Egardt B: Unification of some adaptive control schemes. Part I - Continuous time. Part II - Discrete time. Oct 1978.

TFRT-7153 Havlíĉek A, Gustavsson I: Dynamical identification of the cooling system in a fluidized bed combustor. Oct 1978.

TFRT-7154 Andersson L, Åström K J: An interactive MISO regulator. Oct 1978.

TFRT-7155 Källström C G: Identification of the steering dynamics of the Sea Swift. Oct 1978.

TFRT-7156 Mattsson S E: A simple real-time scheduler. Nov 1978.

TFRT-7157 Källström C G: Identification of the steering dynamics of Sea Stratus. Nov 1978.

TFRT-7158 Olsson G: Swedish experiences of instrumentation and control of wastewater treatment plants. Dec 1978.

TFRT-7159 Olsson G: Experiences Suedoises relatives a l'instrumentation et a la regulation en stations d'epuration. Dec 1978.

TFRT-7160 Olsson G: Processreglering i reningsverk - en översikt (Process control in wastewater treatment plants - a survey). Dec 1978.

TFRT-7161 Sternby J: A review of extremum control. April 1979.

TFRT-7162 Bell R D, Åström K J: A low order nonlinear dynamic model for drum boiler-turbine--alternator units. April 1979.

TFRT-7163 Åström K J, Bell R D: A simple drum level model. May 1979.

TFRT-7164 Åström K J: Algebraic system theory as a tool for regulator design. May 1979.

TFRT-7165 Bergman S-Å, Bjerke O, Dymling S, Grgiĉ A, Grimsberg M, Henningsson B, Kleverman M, Månsson L, Nielsen L, Svensson G: Reglering av farkoster (Control of vehicles). March 1979.

TRAVEL REPORTS

TFRT-8022 Åström K J: Visit to the Department of Automatic Control, ETH, Zürich, February 1977. May 1977.

TFRT-8023 Wittenmark B: Travel report from USA - July 1, 1977 - July 3, 1978. Oct 1978.

APPENDIX D - COURSES AND SEMINARS AT THE DEPARTMENT

Undergraduate courses, graduate courses, seminars as well as external courses, given at the department during the years 1977/78 and 1978/79, are summarized here. They are given both by the staff at the department, and by invited lecturers.

Undergraduate courses

Linear systems (Reglerteknik AK)
Principles of automatic control
Control theory for chemical engineers
Nonlinear and sampled data systems
Systems engineering
Computers in control systems I and II

Ph D Courses

The following courses have been given:

Optimization methods (P Hagander)
Stability theory (P Hagander)
Stochastic control theory (P Hagander)
Methods for the analysis and characterization of physiological phenomena. Graduate course for medical students, Lund (20 lectures) (P Hagander)
Control system design (I Horowitz (Israel), M Mansour (ETH Zürich), K J Åström, A Foss (Berkeley, Calif))
Identification (K J Åström)
Adaptive control (K J Åström)
Linear system theory (K J Åström)

Seminars

1977

Sep 1 — Jan Holst: Local convergence of some recursive estimation algorithms.

Sep 5 — Jan Holst: ARMA process prediction.

Sep 9 — Jan Holst: Adaptive prediction.

Sep 20 — Prof M Mansour (ETH Zürich): Schwarz matrix form in the analysis of continuous and discrete systems.

1977

Sep 22 M Mansour: Quadratic performance indices and the margin of stability for linear continuous and discrete systems.

Sep 29 Per Hedelin (Chalmers Inst of Technology, Göteborg): Reduced order smoothing.

Sep 30 Leif Andersson: An introduction of the LSI 11 computer.

Oct 6 Jan Sternby: Grinding of rocks.

Oct 7 Prof Göran Einarsson (Dept of Telecommunication Theory, Lund): Differential PCM.

Oct 14 Torkel Glad: Impressions from a year in the USA.

Oct 18-27 Prof Isaac Horowitz (Weizmann Inst of Science, Israel): Quantitative synthesis techniques and plant uncertainty. Six seminars.

Oct 28 Ivar Gustavsson and Jan Sternby: Self-tuning prediction.

Nov 10 Bo Egardt: Model reference adaptive systems.

Nov 11 K J Åström: Linear quadratic control synthesis, Introduction.

Nov 18 Dr Göran Salomonsson (Dept of Telecommunication Theory, Lund): Adaptive equalizers.

Nov 23 N Leth (DTH, Lyngby, Denmark): Design of a servo system.

Dec 19 Prof Ruth Curtain (Gronningen, the Netherlands): Controllability and observability concepts for infinite dimensional systems.

1978

Jan 25 Jan Sternby: Begränsningar vid adaptiv styrning (Performance limits in adaptive control).

Feb 8 K J Åström et al: Ett processtyrningsspråk (A new process control language).

Feb 17 Per Hagander: Stability theory, Introduction.

Feb 23 Hilding Elmqvist: Introduction into the Dymola language.

1978

March 1, 3, 10	Per Hagander: Stability theory.
March 17	Curt Wells (Dept of Economics, Lund univ): Optimal economical policy.
March 21	Johan Wieslander: New interactive programs: MODPAC.
Apr 14	Dr Toni Havlichek (Prague): Statistical modeling and analysis of chemical processes.
Apr 21	Lars Pernebo: Algebraic design theory I.
Apr 24	Prof John Rijnsdorp (the Netherlands): Man's role in control systems.
Apr 28	Lars Pernebo: Algebraic design theory II.
May 8	Lars Pernebo: Albegraic design theory III.
May 9	Prof Alan Foss (Univ of California, Berkeley): Survey of research on chemical reactor control.
May 10	Alan Foss: Dynamic models of fixed-bed reactors.
May 12	Alan Foss: Parameter determination for reactor model.
May 16	Alan Foss: Development of control system configuration.
May 17	Alan Foss: Reconstruction design and experimental results.
May 19,26	Hilding Elmqvist: A structured model language for large continuous systems, I and II.
May 26	Hilding Elmqvist: Compiler technique, formula treatment and the Dymola compiler.
May 31	Svante Jahnberg (Research Institute of National Defense (FOA), Stockholm): Microcomputers - some development features.
June 2	Prof Howard Rosenbrock (UMIST, Manchester, England): Representation of state.
June 6	Prof Peter Falb (Brown univ, Providence RI, USA): Linear systems with variable parameters I.

1978

June 7 Peter Falb: Linear systems with variable parameters II.

June 7 Prof M Athans (MIT, Cambridge, Mass, USA): Toward reliable control system synthesis.

June 7 Dr Austin Spang III (General Electric, Schenectady, USA): Insight into the application of the inverse Nyqvist array method to turbofan engines.

June 8 Prof I D Landau (Grenoble, France): Bilinear modelization of distillation columns.

June 8 M Athans: Systems aspects of complex manufacturing networks.

June 8 Prof Tim Johnson(MIT, Cambridge, Mass, USA): On-line identification of bio-electrode parameters.

Aug 28 Dr Mike Grimble (Sheffield, England): Finite time optimal control in the s-domain.

Aug 30 M Grimble: S-domain solution of the filtering problem.

Sep 4 Prof Don Wiberg (UCLA, Los Angeles, USA): Applications of parameter identification to respiratory physiology.

Sep 7 Dr Lou Westphal (Univ of Queensland, Australia): Parameter identification by systematic variation of partitioned adaptive filters.

Sep 9 K J Åström: Linear quadratic or frequency domain methods?

Sep 13 Björn Wittenmark: A two-level estimator.

Sep 14 Dr G Favier (L'université de Nice, France): New stochastic realization algorithms for identification of ARMA models.

Sep 15 Prof R W H Sargent (Imperial College, London, England): Selection of measurements for optimal feedback control.

Sep 19 Dr Rod Bell (MacQuarie Univ, Australia): Model and control studies for large power generating plants.

Oct 20 Björn Wittenmark: Impressions from a year in USA.

1978

Oct 26 K J Åström: Self-tuning regulators based on pole-placement design I.

Nov 17 K J Åström: Self-tuning regulators based on pole-placement design II.

Nov 30 Dr David Hill (Univ of Melbourne, Australia): Hierarcal systems.

1979

Feb 13 Prof Raman Mehra (SSI, Cambridge, USA): Non-linear systems and bifarcation.

March 9 Dr Lazlo Kevizcky (Budapest, Hungary): Non-linear identification in the practice of DATUB closed loop grinding mill models.

March 13 Prof Steve Morse (Yale Univ, New Haven, USA): Decentralized control.

March 14 S Morse: Transportation system scheduling.

March 15 S Morse: Adaptive control.

March 19 Prof R Mohler (Oregon State Univ, Portland, USA): Overview of bilinear systems.

March 20 Per-Olof Gutman: Controllers for bilinear systems.

March 21 R Mohler: Process control applications of bilinear systems.

March 30 Civ ing Dan Andrée (KTH, Stockholm): Dynamical systems with abrupt changes of coeffi-cients.

May 15 Övering Jonas Agerberg (FOA, Stockholm): ADA.

May 15 Prof André Titli (LAAS, Toulouse, France): Hierarcal systems.

May 16 Dr Vladimir Kucera (Czeckoslovak Academy of Science, Prague, Czechoslovakia): Polynomial equations approach to design of controllers.

May 17 Prof Neil Munro (Manchester Univ, Manchester, England): Application of inverse Nyquist.

June 7 Prof N A Lindberger (KTH, Stockholm): Random walk between reflecting walls - A family of test signals for nonlinear systems.

1979

June 11 Dr George Axelby (Westinghouse, Baltimore, USA): Reflections on computations in control - An industrial viewpoint.

June 12 Per Molander: A system analysis symposium.

June 21 Dr Gerry Bierman (JPL, Pasadena, USA): Numerical aspects of control and estimation.

External courses

I. Climate control in buildings.
The course was held 22-24 May 1978 and given for industrial and university people. It included the following lectures:

1. K J Åström: Control of climate processes, an introduction.

2. G Olsson: Disturbances, models, control, a survey.

3. L Jensen: Dynamical properties of climate processes. Room dynamics, air flow channels, heat exchangers.

4. K J Åström: Simple controllers. Feed forward, feedback.

5. L Jensen: Self-tuning regulators. Application on a heat pump.

6. G Olsson: Simulation as a design tool.

7. G Olsson: The computer as a component in climate systems.

8. L Jensen: Computer control. Start-up, supervision, control. A special control language.

9. K Andersson (Skånska Cementgjuteriet, Stockholm): Practical applications.

II. Introductory control theory.
This was given as a one-day seminar for food technology students, April 1978.

III. Process identification.
Two identical four-day courses were held April 2-5, 1979, and May 8-11, 1979, and given for industrial

people. The following lectures were given:

1. K J Åström: Process identification - Introduction.
2. B Wittenmark: Frequency and transient analysis.
3. I Gustavsson: Correlation analysis.
4. J Wieslander: Interactive programs.
5. J Sternby: The least squares method.
6. B Egardt: The maximum likelihood method.
7. G Olsson, I Gustavsson: Experiment planning.
8. K J Åström: Process identification - a survey.
9. C G Källström, B Egardt: Applications.
10. B Egardt: Adaptive control.

APPENDIX E - LECTURES BY THE STAFF

1977

Aug 5	K J Åström: System identification. Univ of Queensland, Australia.
Aug 17	K J Åström: Adaptive control. Univ or New South Wales, Australia.
Aug 23--Sep 2	K J Åström: Stochastic control theory (six lectures). Australian National University, Camberra. Published in W A Coppel (ed): Mathematical Control Theory, Springer Verlag, 1978.
Sep 7	K J Åström: Modeling and optimization - an overview. Symposium on mathematical modeling in food processing, Örenäs, Sweden.
Fall	Björn Wittenmark: Identification of dynamic systems (14 lectures, 42 hours). Univ of Connecticut, USA.
Sep 14	Claes Källström: Description of the adaptive autopilot for tankers. Simulations and experiment. Lectures at the Kockum Shipyard, Malmö, Sweden.
Sep 20	Björn Wittenmark: Design of digital controllers. Univ of Connecticut, USA.
Sep 26	Claes Källström: Maximum likelihood estimation of coefficients in the dynamic equations. Course on "Maneuvring of Marine Structures", NTH, Trondheim, Norway.
Sep 30	Bo Egardt: Modell-referens regulatorer (Model reference adaptive regulators). Dept of Electrical Engineering, Linköping University, Sweden.
Oct 4-5	Claes Källström: Identification of ship dynamics. Interactive program for the simulation of dynamic systems - Simnon. Simulation of control systems for super tankers. 3 lectures in a course on interactive program systems, NTH, Trondheim, Norway.
Oct 12	Björn Wittenmark: Self-tuning algorithms for control, prediction and smoothing. Honeywell, Minneapolis, USA.

1977

Oct 18 Björn Wittenmark: Self-tuning algorithms for control, prediction and smoothing. Univ of Massachusetts, Amherst, USA.

Oct 28 Per Molander: Convergence of recursive stochastic algorithms with applications to system identification. Gronningen University, the Netherlands.

Nov 14-17 Johan Wieslander: Modern control theory. 3 lectures at a course on computers in the process industry, Huskvarna, Sweden.

Nov 23 G Olsson: Interactive programming. Danish Institute of Technology, Lyngby, Denmark.

Dec 9 Jan Holst: Adaptive prediction, theory and applications. Linköping University, Sweden.

1978

Jan 10-11 Jan Sternby: Dual control. Self-tuning regulators. Dept of Statistics, Umeå Univ, Sweden.

Jan 17 Björn Wittenmark: Self-tuning algorithms for control, prediction and smoothing. Case Western Reserve University, Cleveland, USA.

Jan 19 Björn Wittenmark: Self-tuning algorithms for control, prediction and smoothing. Univ of Minnesota, Minneapolis, USA.

Feb 14 Björn Wittenmark: Introduction to self-tuning regulators. Univ of Connecticut, USA.

Feb 21 Björn Wittenmark: Self-tuning regulators - the algorithm. Univ of Connecticut, USA.

Feb 23 Björn Wittenmark: Self-tuning algorithms for control, prediction and smoothing. Rensselaer Polytechnic Institute, Troy, USA.

Feb 28 Björn Wittenmark: Self-tuning regulators - the properties of the algorithm. Univ of Connecticut, USA.

March 7 Björn Wittenmark: Self-tuning regulators - pole placement algorithms. Univ of Connecticut, USA.

March 13 G Olsson: Dissolved oxygen control. Water Research Centre, Stevenage, England.

1978

April 4 Björn Wittenmark: Self-tuning algorithms for prediction and smoothing. Univ of Connecticut, USA.

April 7 K J Åström: Application of self-tuning regulators. Science Research Council, Vacation School on Stochastic Processes in Control Systems, Univ of Warwick, England.

April 10 -13 Johan Wieslander: Modern control theory. Repeat of the course fron Nov 14-17, 1977.

April 11 Björn Wittenmark: Industrial applications of self-tuning regulators. Univ of Connecticut, USA.

April 18 K J Åström: Self-tuning regulators with deterministic inputs. Univ of Grenoble, France.

May 2 Björn Wittenmark: Self-tuning algorithms for control, prediction and smooting. Invited presentation at the Institute of Mathematical Statistics Meeting on Time Series Analysis, Iowa State University, Ames, USA.

May 8 Björn Wittenmark: Adaptive control - industrial tool or academic toy. Univ of Connecticut, USA.

May 10 Ivar Gustavsson: Process identification - Experiences from different applications. Dept of Electrical Engineering, Linköping University, Sweden.

May 17 Gustaf Olsson: Automatic control in combined wastewater treatment plants. Int Environmental Colloquium, Liége, Belgium.

May 24 Per Molander: On the design of high-gain feedback regulators and observers. Twente Tekniska Högskola, Enschede, the Netherlands.

May 31 Björn Wittenmark: Self-tuning algorithms for control, prediction and smoothing. McGill University, Montreal, Canada.

May 31 Jan Holst: Adaptive prediction of electric power consumption. Luleå Institute of Technology, Luleå, Sweden.

June 2 Björn Wittenmark: Suboptimal minimum energy controllers for process control. Symposium on Simulation, Modelling and Decision in Energy Systems, Montreal, Canada.

1978

June 12 Jan Holst: Some practical applications of stochastic control theory. Summer school, Swedish Statistical Soc, Saltsjö-boo, Sweden.

June 12 - 16 IFAC World Congress, Helsinki, Sweden.
Claes Källström and K J Åström: Adaptive autopilots for large tankers.
Jan Sternby: A regulator for time-varying stochastic systems.
K J Åström: Invitation presentation for Round table on the next decade of control theory and applications. (See Automatica 15 (1979) 361-363).

June 17 Jan Sternby: Dual control. Summer school, Swedish Statistical Soc, Saltsjö-boo, Sweden.

June 29 Björn Wittenmark: Self-tuning algorithms for control, prediction and smoothing. Yale University, New Haven, USA.

Aug 15 G Olsson: The use of the dissolved oxygen profile as a tool for activated sludge control. Research lab, Metropolitan Sanitary District of Greater Chicago, Chicago, USA.

Aug 30 K J Åström: Självinställande regulatorer (Self-adjusting regulators). Servolaboratoriet, DTH, Lyngby, Denmark.

Sep 18 K J Åström: Adaptive autopilots for ship steering. Electronic Systems Laboratory, MIT, Cambridge, USA.

Sep 19 K J Åström: Self-tuning regulators with deterministic inputs. Harvard University, Cambridge, USA.

Sep 20 K J Åström: Adaptive controllers based on pole zero assignments. Brown University, Providence, RI, USA.

Sep 21 K J Åström: Adaptive control. Yale University, New Haven, Connecticut, USA.

Sep 26 K J Åström: Adaptive control - a survey. General Electric Research Lab, Schenectady, USA.

Sep 26 K J Åström: Progress in control theory. Int Symp on Process Control for the Pulp and Paper Industry, Monterey, California, USA.

1978

Oct 12 Lars Pernebo: Algebraic design theory. Univ of Southern California, Los Angeles, USA.

Nov 9 K J Åström: Framsteg inom reglertekniken (Progress in control theory). SPCI Svenska Pappers- och Cellulosa Ingenjörsföreningen, Stockholm, Sweden.

Nov 15 K J Åström: Adaptiv reglering (adaptive control). University of Aalborg, Denmark.

Nov 21 Lars Pernebo: Algebraic design theory for linear multivariable systems. Stanford Univ, Stanford, California, USA.

Nov 21 K J Åström: Self-tuning regulators - Design principle and applications. Univ of Leuven, Belgium.

Nov 22 K J Åström: Self-tuning regulators - Theory. Univ of Leuven, Belgium.

Nov 23 K J Åström: State of the art of system identification. Univ of Brussel, Belgium.

Nov 29 G Olsson: Control of wastewater treatment plants - a survey (in Swedish). Swedish section of Water Pollution Control Federation, Stockholm, Sweden.

Dec 1 G Olsson: Swedish experiences of instrumentation and control in wastewater treatment plants. Institute Recherche Chimie Applique, Paris, France.

Dec 5 K J Åström: A survey of adaptive control. LAAS, Toulouse, France.

Dec 5 K J Åström: Design of self-tuning regulators. CERT/DERA, Toulouse, France.

Dec 7 K J Åström: Adaptive regulators based on pole placement design. Univ of Grenoble, Grenoble, France.

Dec 12 K J Åström: Piece-wise deterministic signals. Int Symp on System Optimization Analysis, IRIA, Rocquencourt, France.

1979

Jan 9	K J Åström: Adaptive autopilots for ship steering. Univ of California, Los Angeles, USA.
Jan 10	K J Åström: Reflections on theory and practice of automatic control. Invited keynote lecture 17th decision and control conference, San Diego, USA.
Jan 15	K J Åström: Self-tuning regulators design principles and applications. Univ of Southern California, Los Angeles, USA.
Jan 17	K J Åström: Self-tuning control of a fixed bed chemical reactor. Dept of Chemical Engineering, Univ of California, Santa Barbara, USA.
Jan 19	K J Åström: Self-tuning regulators based on pole placement design. Univ of California, Berkeley, USA.
Jan 22	K J Åström: Principles of adaptive control. Stanford University, USA.
Feb-March	Lars Pernebo: Polynomial matrices and system theory. A series of lectures at University of Southern California, Los Angeles, USA.
April 6	Sven Erik Mattsson: Implementation of Concurrent Pascal. ETH, Zürich, Switzerland.
April 27	K J Åström: Syntes av observerare och regulatorer genom polynommanipulation (Synthesis of observers and regulators using polynomial manipulation), Inst för Optimeringslära och Systemteori, KTH, Stockholm, Sweden.
May 5	Lars Pernebo: Algebraic design theory for linear multivariable systems. University of California, Berkeley, USA.
May 28--29	Ivar Gustavsson: Presentation and demonstration of IDPAC. Teknicum, Uppsala, Sweden.
June 1	Per Molander: Styrning av tekniska system (Control of technical systems). SOAF Conference, KTH, Stockholm, Sweden.

APPENDIX F - TRAVELS

Karl Johan Åström visited Australia in August-September, 1977, where he lectured at University of Queensland, University of New South Wales, and Australian National University. October 3-5, 1977, he participated at the meeting in Düsseldorf of the International Program Committee for the 1978 IFAC World Congress. From December 5, 1977, to January 28, 1978, he visited Imperial College, London. He participated in the IFAC World Congress in Helsinki, June 12-16, 1978. In September, 1978, he lectured at several universities in USA and attended an international symposium on process control for the pulp and paper industries in Monterey, California, USA. On December 12, 1978, he presented a paper at the International symposium on system optimization analysis, IRIA, Rocquencourt, France. He presented a key note lecture at the 17th CDC in San Diego, USA, in January 1979.

Hilding Elmqvist visited the Computer Science Department at Stanford University, California, during the period Aug 15, 1978 - Aug 15, 1979. The time was shared between attending courses, working in a compiler project concerned with extensions to Pascal, and own research mainly consisting of design of language features for description of man-machine interaction.

Per-Olof Gutman has been at the Engineering Systems and the Systems Science Departments, University of California, Los Angeles, as an exchange student during the academic years 1976-78. The main topic of the studies has been biological applications of automatic control. A MSc Engineering degree was achieved in June 1977. Gutman has been lecturing an undergraduate course "Patterns of problem solving" during 1977-78. During the stay in USA he has been visiting numerous universities, industries, and conferences, e.g. Stanford University, NASA Edwards Air Force Base, Measurex Corporation, Capertino Calif, and the Joint Automatic Control Conference in San Francisco, June 1977.

Per Hagander visited the VIIe Colloque International du College de France sur le Thême:"L'Idée de Régulation dans le Mouvement des Sciences" in Paris, December 5-10, 1977. He also attended a symposium on Software for Numerical Optimization, held in London March 10-12, 1978.

Claes Källström visited the division of ship hydrodynamics, the Norwegian Institute of Technology (NTH) in Trondheim on September 25-29, 1977, giving a lecture in a course on Maneuvering of Marine Structures. He visitied NTH again on October 4-5, 1977, this time at the Division of Engineering Cybernetics to give lectures at a course on Interactive programs. Finally he attended the IFAC World Congress in Helsinki, Finland, June 1978, and presented a paper.

Sven Erik Mattsson attended an informative meeting "Ada = Strawman - Konman - Dodula" (The U.S. Department of Defense Common High Order Language program) arranged by FOA (National Defense Research Institute) in Stockholm, January 30, 1979. He also attended the course "The Programming Language Pearl" in Studsvik, January 31 - February 1, 1979. He participated in "European Workshop on Industrial Computer Systems", Perdue Europe Regional Meeting, Zürich, Switzerland, April 3-5, 1979. In connection to that he visited "Fachgruppe für Automatik", ETH, Zürich.

Per Molander spent the academic year Sep 1977 - May 1978 at the Department of Mathematics, Division of Systems Theory at the Groningen University, Netherlands. He was joining the research group with Professor J C Willems.

Gustaf Olsson was invited to the University of Houston, Texas, USA, during June and July 1977 as a visiting scientist. In March 1978 he spent a week at different institutions in England. He visited Thames Water Author Authority in London, Water Research Centre in Stevenage, and the Whitlingham sewage treatment plant in Norwich. On May 16-18, 1978, he participated in a meeting called International Environmental Colloquium in Liége, Belgium, and presented an invited paper. In June 1978 he attended the IFAC World Congress in Helsinki. He was invited to the University of Houston, Texas, as a guest scientist during July and August 1978. On December 1-2, 1978, he was invited to lecture at an international course on wastewater treatment control, arranged by the Institute Recherche Chimie Applique in Paris. In May 1979 he was invited to the International Environmental Colloguium in Liége, Belgium, to present a paper.

Lars Pernebo visited the USA from September 12, 1978, to September 28, 1979. From Sep 12, 1978, to July 1, 1979, he worked with Prof Silverman's group at Univ of Southern California, Los Angeles, California. The research included investigation of balanced state space representations and model reduction procedures. He visited the Information Systems Laboratory at Stanford

University, Stanford, California, between Nov 15 and 23, 1978, and between May 28 and 30, 1979. He also visited the Department of Electrical Engineering at Univ of California at Berkeley, California, on May 25, 1979. Between Jan 10 and 12, 1979, he participated in the CDC conference in San Diego, California.

Jan Sternby attended the IFAC World Congress in Helsinki, June 1978, and presented a paper.

Björn Wittenmark spent the academic year at the Univ of Connecticut, USA, as a visiting professor. During the year he made several visits to other universities, industries, and conferences. He attended the IEEE conference on control and decision in New Orleans, December 1977. He also made visits to Honeywell, Minneapolis, Univ of Massachusetts, Amherst, Case Western Reserve University, Cleveland, Univ of Minnesota, Minneapolis, Rensselaer Polytechnic Institute, Troy, Iowa State University, Ames, McGill University, Montreal, Yale University, New Haven. He also attended a symposium on simulation, modeling and decision in energy systems, Montreal, Canada.