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ACTIVITY REPORT

1987–1988

Editors: Eva Dagnegård
Lars Nielsen

**Department of Automatic Control
Lund Institute of Technology**

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1. Introduction

This report covers the activities of the department during the period 1 July 1987 – 30 June 1988, which is the academic year 1987/88.

Substantial efforts have been made to renew the courses and teaching laboratories. Work is going on to significantly extend the curriculum by the addition of courses in identification and in adaptive control. The teaching laboratory for the digital control courses has been completely renewed and the courses on computers in control systems have been significantly changed. In summary 558 students have taken one or several of the eight courses that are given by the department. Further description is given in Section 2.

Research has continued in established areas such as adaptive control and computer aided control engineering. Several full scale application projects have also been carried out in power network stability, boiler turbine modeling, wastewater treatment and biotechnical processes. These projects are described in Section 3.

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

The SSAB Symposium, Swedish IAPR Symposium on Image Analysis was held at the department during March 10–11, 1988. Further details are given in Section 5.

We want to thank our sponsors, the Swedish Board for Technical Development (STU), the Swedish Council for Planning and Coordination of Research (FRN), the Swedish Board for Energy Source Development (NE), Sydkraft, Vattenfall, 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 D.

2. Education

Undergraduate Courses

Automatic control courses are taught as a part of the engineering curricula in Engineering Physics (F), Electrical Engineering (E), Computer Engineering (D), Mechanical Engineering (M), and Chemical Engineering (K).

During the year the following courses were given at the department:

Name of the course (Section)	Number of students
Reglerteknik AK (F, E, D) (Automatic control, linear systems)	250
Reglerteknik AK (M) (Automatic control, linear systems)	92
Processreglering (K) (Process control)	79
Digital reglering (F, E, D) (Computer controlled systems)	95
Systemteknik (M) (Systems engineering)	2
Tillämpad realtidsprogrammering (F, E) (Applied real-time programming)	14
Processidentifiering (F, E, D) (Process identification)	12
Adaptiv reglering (F, E, D) (Adaptive control)	14

The figures give the number of students that have passed the courses during 1987/88.

New Courses

A new course in process identification (Processidentifiering) at the masters level was developed and given at the department. The course is

scheduled for the 9th semester of studies and is directed towards students of engineering physics, electrical engineering and computer science. The course covers nonparameteric identification, time series analysis, modeling, structure determination, validation, model reduction, 2D-methods and nonlinear system identification. The course has 28 hours of lectures, 14 hours of tutorials, four laboratory sessions, and one project.

A new course on adaptive control (Adaptiv reglering) at the masters level has been introduced. The course is based on a new textbook: *Adaptive Control* by Åström and Wittenmark. The course covers: overview, recursive parameter estimation, model reference adaptive systems (MRAS), self-tuning regulators (STR), adaptive control theory, stability, averaging, auto-tuning, gain-scheduling, implementation, applications, and perspectives. The course has 28 hours of lectures, 14 hours of tutorials and four laboratory instruments. Computer aided simulation tools (Simnon) were used in the course. There was also a project in the course. The first course was followed by 25 students.

Master Theses

The students exhibited an increasing interest in master thesis work in the control area. Fourteen master theses were completed by sixteen students during the year.

The theses concerned the following application areas: power systems (4), biomedical engineering (1), computer aided design (2), operating systems (2), process control (2), production systems (1), robotics (3), and servomechanisms (1).

A list of the MSc-theses is given in Appendix D.

Graduate Courses

One PhD thesis and one Lic Tech thesis were completed during the period. One new PhD student was admitted to the department.

The following PhD courses have been given:

Education

Linjära system 10 p (P. Hagander) (Linear systems), 7 participants	fall 1987
AI-programmering 6 p (W. Kreuzer, K. J. Åström) (AI-programming), 5 participants	winter 1987-88
Syntes 8 p (K. J. Åström, P. Hagander) (Design of control systems), 12 participants	spring 1988

Extension Courses

The extension program in automatic control offers courses for extended education of engineers in industry. The following courses have been given during the period:

Process identification	21-24 September 1987
Adaptive control	20-22 October 1987
Survey of control theory	24-27 May 1988

All courses demand 3-4 days of attendance and take 16-20 participants. Each day of a course usually consists of two or three lectures and a laboratory session of about four hours.

3. Research

Research at the department concerns theory and applications. The main research areas have been:

- Adaptive control
- Computer aided control engineering
- Expert control
- Robotics and sensory control
- Power systems
- Control of a biotechnology processes
- Modeling and control of medical systems

The areas are highlighted below.

Adaptive Control

Adaptive control has been pursued with support from STU under contract 85-3225. Research under this contract was completed in June 1988. A final report is under preparation. The project has covered multivariable adaptive control, dual control theory, and automatic tuning of simple regulators. Full details are given in the final report for the project, which contains many references.

Adaptive control of an industrial robot has been investigated. Comparisons between robust and adaptive control have also been made. The senior researchers are Rolf Johansson, Björn Wittenmark, and Karl Johan Åström. The PhD thesis *Adaptive Stabilization* by Bengt Mårtensson was completed during this project. Manuscripts for two books have been completed: *Automatic Tuning of PID Controllers* by K. J. Åström and T. Hägglund, and *Adaptive Control* by K. J. Åström and B. Wittenmark. Proceedings from the IFAC Workshop *Adaptive Systems in Control and Signal Processing 1986* also appeared.

Computer Aided Control Engineering (CACE)

During the two last years (July 1987 – June 1989) of the STU financed research project "Computer Aided Control Engineering, CACE" the efforts are focused on tools for model development and simulation.

The aim is to introduce some new ideas and concepts that we think are useful. We are especially focusing on system representation. It is an important and critical part of a CACE system, since it should be made common to all tools. A basic idea is that model development could be supported by facilitating reuse of models so that a model could be used for various tasks and so that it is easy to modify a model to describe plants of similar type. It seems as developers of today's simulation tools have neglected this possibility to support model development.

We propose that declarative forms (equations) should be used to describe the behavior of models. Declarative models on symbolic forms can be used in various contexts, since they can be manipulated automatically to generate efficient code for simulation, code for calculation of stationary points, linear representations, efficient control code, descriptions which are accepted by other existing packages etc.

Another complementary approach to support development of new models as well as reuse of models is to support a number of model structuring concepts. The most important is hierarchical submodel decomposition. It means that a model can be decomposed into submodels, which in turn can be decomposed into submodels. This concept allows a mapping of the component structures of real plants. Thus supporting reuse of parts of models and building of component model libraries. Our concepts to define interactions between submodels allow the model developer to supply redundant information to support automatic consistency checks. It is important to make the use of library models safe and reliable. Another structuring concept allows a model to have multiple descriptions of its behavior. One model cannot cover all aspects. We have also one concept to structure model libraries. A model is also allowed to have several presentation forms. Different users would like to have different views of a model.

We believe that all users can agree on the basic semantics of these concepts, but that it is useful to allow the concepts to have different textual and graphical representations. For example as a graphical presentation of the model structure, we propose hierarchical block diagrams with in-

formation zooming. Our design includes also an internal representation to support these concepts. A prototype implementation is done using KEE.

We are also running an application project aimed at modeling of chemical processes. It serves several purposes: source of inspiration, test case for ideas and concepts, test case for implementation and demonstration model to illustrate our ideas.

Expert Control

Research on expert control has been funded by STU since 1985. The goal of expert control is to extend the range of conventional controllers by encoding general control knowledge and heuristics concerning tuning and adaptation in a supervisory expert system. An important part of the project is architectures for real-time on-line expert systems. During spring 1988 the Department has participated in a feasibility study about knowledge-based control funded by the national IT4 research program together with local industries. The responsible researcher is Karl-Erik Årzén.

Robotics and Sensory Control

A laboratory for robotics and sensory control has been initiated. The experimental work is centered around an Asea Irb-6 robot. Hardware interfaces has been developed around new chips for resolver to digital conversion. Other experimental setups are a separate Asea Irb-6 DC-servo motor with the same interfaces, and setups around different versions of a DC-servo developed at the department. Among these setups there is a robot simulator based on two such DC servos connected via a signal processor based on TMS 32010. The software used is based on the language Modula-2 and on a real-time programming environment developed at the department. The hardware is an IBM-AT. Using this environment a number of prototype robot control programs has been tested in education and master theses work. The responsible researcher is Lars Nielsen.

Power Systems

A research program in power systems has been running for a couple of years. The program is funded by Vattenfall, Sydkraft, and Statens Energiverk (STEV). Vattenfall and Sydkraft are sponsoring a guest professorship and STEV a research assistant. The intention of the program is to start a long range development within the field of power systems. The guest professorship has during the year been held by David Hill, University of Newcastle, and Rod Bell, Macquarie University. A cooperation with the Electric Power Engineering Department at DTH in Lyngby has started. Two students from Lund have followed courses in Power Systems during the last year.

Power system stabilization. The purpose of this project is to improve the understanding of the power system stabilization problem. The Nordel system has suffered from two disturbances due to undamped power swings during the last five years. A large number of power system stabilizers have been installed during the past 15 years. There is unfortunately no method for experimental verification of the performance of such stabilizers during system-wide power swings. One part of the project was to survey possible means and methods for improving the damping of power system swings. Another part was to develop techniques to tune existing power system stabilizers. A third part was to explore new types of power system stabilizers. There may be a potential to explore power system stabilizers based on Kalman filtering methods, adaptive control and self-tuning regulators.

The work was based on the aggregated 12 machine model of the Nordel system. This model, which was originally developed by Vattenfall, is now widely used and trusted within Nordel. Methods for stability analysis have been developed with special emphasis on the selection of locations of stabilizing equipment. The project has been supervised by Professor David Hill and B. Wittenmark.

Thermal power unit. Professor Rod Bell returned to Lund for a shorter follow-up on the simulation models for boiler-turbine units together with K. J. Åström and a group at Sydkraft. The models have been further developed and accurate nonlinear models can now be derived from construction data of the plants. The models have been compared with actual plant data. A major contribution of the models in the prediction of drum water level. The swell/shrink phenomena is quite accurately captured even though the models are of low order.

Control of Biotechnology Processes

A joint project with the Division of Biotechnology, Chemical Center, on control in biotechnology processes has been funded by STU since 1983. The purpose of the work is to investigate the possibilities for process control using direct measurements of substrate, product and intermediates in the processes. Newly developed biosensors have been applied to fed-batch production of baker's yeast. Here measurement of ethanol concentration gives a sensitive indication of the metabolic state of the cells. Identification experiments are performed in closed loop, and parameter estimation is done for models with partially known dynamics. Some optimal control problems are also formulated and investigated using nonlinear control theory.

A new direction of the work is started up. The bacteria *Pseudomonas Cepacia* is grown on the toxic substrate salicylate to produce the enzyme salicylate hydroxylase. The enzyme is used in clinical chemistry to determine salicylate in blood samples. The purpose of the work is to control the substrate addition to be enough for growth without any adverse effect from its toxicity. A spectrophotometric sensor is developed, and experiments are performed using PI-control around a basic substrate flow scheme.

Modeling and Control of Medical Systems

A few projects have been done in the field signal processing and control theory applied to medical problems. The responsible researcher is Rolf Johansson.

Two projects treat estimation of parameters related to human posture dynamics. The work is performed in cooperation with Dr Máns Magnusson at the Department of Oto-Rhino-Laryngology, Lund University Hospital. The stability investigation is made with induced body sway by galvanic or vibratory stimuli. The goal is to find parameters that describe the human ability to maintain posture. The method is intended for use in diagnosis and rehabilitation of human balance disorders.

4. Computer Facilities

The total computer capabilities of the department has been extended with a number of personal computers and workstations, and are as follows:

- **VAX-11/780** with 10 MB memory and 750 MB disk. The most important programs are Pro-Matlab, Macsyma, CtrlC, T_EX, Lisp and our own packages Simnon and Idpac.
- Fourteen **IBM-AT** or compatibles with 640 kB memory and 20 MB disk. They have analog input and output channels (4 or 16 channels in and 2 or 8 channels out) and also some digital I/O. The main use of these computers is for real time control, both in formal lab exercises and projects in the undergraduate courses, and also in research projects by graduate students and faculty. The programming is done almost exclusively in Modula-2, and a library containing a real time kernel and real time graphics has been developed. This library has reached such a state of maturity that researchers wishing to perform a control experiment can concentrate on the control algorithm and let the library take care of the problems of real-time programming. The achievable sampling rates is up to 100 Hz.

The same computers are also used for control design. Interfaces are provided to PC-Matlab and to our own new PC-Simnon, so that parameters obtained in a design can be transferred both to Simnon for simulation using a nonlinear model, and to the Modula-2 system for control of the real process.

The PC-Simnon is very easily available and has grown to a great success.

- Four **Macintoshes**, used for text processing and for creating figures and drawings for the technical reports. A special program on the Vax enables the inclusion of drawings produced on the Macintosh directly into T_EX documents produced on the Vax.
- Two **Macintosh II** intended for development of control engineering software in a Macintosh environment.

- **An Iris Workstation** with 6.5 MB memory, 150 MB disk and powerful color graphics with 1024×780 pixels and 24 bitplanes. This computer is used mainly in the CACE project described elsewhere in this report.
- **A Sun Workstation network** containing a file server, Sun 3/180 with 800 MB disk and 7 workstations Sun 3/50 with 4 MB memory and a 3/110 with 16 MB memory and color graphics.
- **A Symbolics 3650 Lisp Machine**

The Vax, the Suns, the Iris, and the Symbolics are connected in a computer network (TCP/IP and ethernet). The Macintoshes are connected in an Apple Local Talk network, and these two networks are connected via a Kinetics FastPath bridge.

5. SSAB Symposium

The yearly SSAB Symposium, Swedish IAPR Symposium on Image Analysis, was held in Lund 10–11 March, 1988. SSAB is the Swedish branch of the International Association for Pattern Recognition (IAPR). The annual national meeting was hosted by the Department of Automatic Control, and Lars Nielsen was the conference chairman.

It was the first time the conference took place in Lund, and the event was met by considerable local interest and it also created a momentum for local research groups to present related work to this forum.

The symposium was divided in two parts. The groups sponsored by the Swedish Board of Technical Development (STU) presented the status of their projects in the first part. The second part of the conference contained presentations of submitted and accepted papers. There were 158 participants mainly from Sweden, and 29 papers were presented. The conference was afterwards complimented by the chairman of SSAB for a smooth and successful organization without incidents, and for a relaxed and friendly environment.

Preprints of the symposium can be obtained from the Department.





The preceding picture was taken in August 1988 and shows most of the members of the department.

You can see: 1. Per Persson, 2. Mats Lilja, 3. Ola Dahl, 4. Per-Olof Olsson, 5. Leif Andersson, 6. Jan Peter Axelsson, 7. Karl-Erik Årzén, 8. Klas Nilsson, 9. Jan Eric Larsson, 10. Karl Johan Åström, 11. Lars Rundqwist, 12. Rolf Johansson, 13. Eva Schildt, 14. Mats Andersson, 15. Michael Lundh, 16. Britt-Marie Mårtensson, 17. Per Hagander, 18. Sten Bergman, 19. Tore Hägglund, 20. Magnus Akke, 21. Bernt Nilsson, 22. Lars Nielsen, 23. Kjell Gustafsson, 24. Björn Wittenmark, 25. Rolf Braun, 26. Eva Dagnegård, and 27. Bo Bernhardsson.

Missing: Dag Brück, Ulf Holmberg, Sven Erik Mattsson, Thomas Schönthal, and Agneta Tuszynski.

A. List of Personnel

The following list shows the status of June 1988 if nothing else is mentioned.

Professor

Karl Johan Åström

Högskolelektorer (Associate professors)

Björn Wittenmark

Per Hagander

Rolf Johansson

Lars Nielsen

Forskningsingenjörer (Research engineers)

Leif Andersson

Anders Blomdell (from January 1988)

Rolf Braun

Sven Erik Mattsson

Tomas Schönthal

Forskningsassistenter och Assistenten

(Research assistants and Teaching assistants)

Magnus Akke

Mats Andersson

Jan Peter Axelsson

Bo Bernhardsson

Dag Brück

Ola Dahl

Kjell Gustafsson

Ulf Holmberg

Jan Eric Larsson

Mats Lilja

Michael Lundh

Bernt Nilsson

Per-Olof Olsson

Personnel

Per Persson

Lars Rundqwist

Anders Svensson (1 Sept 1987 – 6 June 1988)

Anders Wallenborg (to 11 Jan 1988)

Karl-Erik Årzén

Institutionssekreterare (Secretaries)

Eva Dagnegård (part time)

Eva Schildt

Agneta Tuszynski (part time)

Assistent (Technical drawings)

Britt-Marie Mårtensson

Visiting Scientists

Professor Rod Bell

Macquarie University, School of Mathematics and Physics,
New South Wales, Australia

(25 Jan – 9 Feb 1988)

Professor J. Douglas Birdwell

Department of Electrical and Computer Engineering,
The University of Tennessee, Knoxville, Tennessee, USA

(2 May – 30 June 1988)

Stephen DeWeerth

Caltech, Pasadena, California, USA

(7 Sept – 2 Oct 1987 and 14–29 June 1988)

Dr Andras Edelmayer

Hungarian Academy of Science,
Computer and Automation Institute,

Budapest, Hungary

(16–27 Nov 1987)

Professor Dean Frederick

Rensselaer Polytechnic Institute,
Electrical Computer and Systems Engineering Dept.,
Troy, New York, USA

(18 May – 17 July 1987)

Dr Per-Olof Gutman
Electro Optical Ind., Rehovot, Israel
(1–21 July 1987)

Professor C. C. Hang
National University of Singapore, Singapore
(1 Aug – 30 Oct 1987)

Dr David J. Hill
University of Newcastle,
Department of Electrical and Computer Engineering,
New South Wales, Australia
(11–29 Jan 1988)

Professor Robert Kosut
Integrated Systems Inc, Santa Clara, CA, USA
(3–18 Sept 1987)

Dr Wolfgang Kreutzer
University of Canterbury, Department of Computer Science,
Christchurch, New Zealand
(1 Dec 1987 – 26 Jan 1988)

Stephen Murphy
Rensselaer Polytechnic Institute, Troy, New York, USA
(1 Sept 1987 – 19 Aug 1988)

Professor Kohei Ohtsu
Tokyo University of Mercantile Marine,
Department of Navigation, Tokyo, Japan
(18 March – 18 Dec 1987)

Special Visits

Thirty students from ENSEM, NANCY (École National Supérieure d'Electricité et de Mecanique), France, visited the department on 18 February 1988.

B. Awards

Karl Johan Åström received the Giorgio Quazza Medal at the IFAC Triennial International World Congress in Munich in July 1987. He was awarded the degree Docteur Honoris Causa from l'Institut National Polytechnique de Grenoble on November 20, 1987. In November 1987 he received the prize as the best EFD teacher for the academic year 86/86 from the EFD Educational board, and in June 1988 he obtained a best presentation award at the American Control Conference in Atlanta, Georgia.

Kjell Gustafsson received the Gene H. Golub Prize, best undergraduate presentation award at SIAM Nordic Section Meeting, 26–27 May, 1988, Bergen.

Erik Mårtensson received the prize ASEA Master Thesis 1987 for the master thesis "Active damping of oscillation modes in a robot arm".

Per Persson received the SAAB-Scania award for graduate students at the SAAB-Scania shareholders' meeting in May 1988.

C. Books, Papers and Conference Contributions

Books

- Åström, K. J., and B. Wittenmark (Eds.) (1987): *Adaptive Systems in Control and Signal Processing 1986*, Proc. 2nd IFAC Workshop, Lund, Sweden, 1–3 July 1986, Pergamon Press, Oxford.
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- Åström, K. J., and B. Wittenmark (1989): *Adaptive Control*, Addison-Wesley, Reading, MA, USA.

Papers and Conference Contributions

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- Årzén, K.-E. (1988): "Expert system applications in process control – A survey (Expertsystemtillämpningar inom processreglering: En översikt)," *Control Meeting '88 (Reglermöte '88)*, Uppsala, Sweden.
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- Johansson, R., and B. Lennartsson D (1988): "Rationella metoder för styrteknik och sekvensstyrning," *Reglermöte '88*, Uppsala, Sweden.
- Johansson, R. (1988): "Human posture performance parameters," *Post Barany Meeting*, Lund, Sweden.
- Johansson, R., M. Magnusson, and M. Åkesson (1988): "Determination of characteristic parameters of human posture dynamics," *9th Int. Symp. on Postural and Gait Research*, Marseille, France.
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- Wittenmark, B. (1988): "Implementation issues in adaptive control," Plenary lecture, *Preprints Workshop on Adaptive Control Strategies for Industrial Use*, Banff, Canada.
- Wittenmark, B. (1988): "Adaptive stability augmentation," *Preprints 8th IFAC Symposium on Identification and System Parameter Estimation*, Beijing, P. R. China.
- Wittenmark, B. (1988): "Implementation and application of adaptive control," Plenary lecture, *Preprints AdChem '88*, Lyngby, Denmark.
- Wittenmark, B., and R. J. Evans (1988): "An adaptive pole placement controller based on pole-zero parameterization," *Preprints 8th IFAC Symposium on Identification and System Parameter Estimation*, Beijing, P. R. China.
- Wittenmark, B., and P.-O. Olsson (1988): "Identification based on asynchronously sampled data," *Automatica*, **24**, 271–273.
- Wittenmark, B., R. J. Evans, and Y. C. Soh (1987): "Constrained pole placement using transformation and LQ-design," *Automatica*, **23**, 767–769.
- Wittenmark, B., R. H. Middleton, and G. C. Goodwin (1988): "Adaptive decoupling of multivariable systems," *Int. Journal of Control*, **46**, 1992–2009.

D. Reports

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

Dissertation

TFRT-1029 Årzén, K. E., "Realization of expert system based feedback control," November 1987.

Lic Tech Thesis

- TFRT-3199 Gustafsson, K., "Stepsize control in ODE-solvers – Analysis and synthesis," June 1988.

Final Report

- TFRT-3190 Johansson, R., "Adaptor a system for process identification and adaptive control. An implementation report," September 1987.
- TFRT-3194 Mattsson, S. E., "Representation and visualization of systems and their behaviour," September 1987.
- TFRT-3195 Brück, D., "Implementation languages for CACE software," September 1987.
- TFRT-3196 Larsson, J. E., and P. Persson, "Experiments with an expert system interface," September 1987.
- TFRT-3197 Johansson, R., "Tre laborationer i processidentifiering och adaptiv reglering," (Three laboratory in process identification and adaptive control), January 1988.
- TFRT-3198 Johansson, R., U. Holmberg, M. Lilja, and M. Lundh, "Laborationer i processidentifiering," (Labworks in process identification), January 1988.

Activity Reports

- TFRT-4015 Dagnegård, E. and P. Hagander, "Activity report 1985–87," July 1987.

Master Theses

- TFRT-5368 Fredenholm, J., "Primitiva adaptiva robotprogram," (Primitive adaptive robot programs), July 1987.
- TFRT-5369 Andersson, K. H., "Filtering of signal from patient scale," August 1987.

- TFRT-5370 Bengtsson, P., "Sökrutin för optimering av effekten i ett vindkraftverk med variabelt varvtal," (Search routine for optimization of the power in a wind power plant with variable speed), September 1987.
- TFRT-5371 Storm, J., "Analys av självsvängningar i neutronflödet i en BWR-härd," (Analysis of resonance oscillations of the neutron flow in a BWR-core), September 1987.
- TFRT-5372 Sjölin, C., "Expertsystem för felsökning vid lackeringslinje på bilindustri," (Expert system for fault diagnosis of a painting line at car industry), September 1987.
- TFRT-5373 Cedell, T., "Modellering av industrirobotsystem," (Modelling of the industry robot system), October 1987.
- TFRT-5374 Kvist, P., "Towards an experimental set-up for robot learning," November 1987.
- TFRT-5375 Granbom, E., and T. Olsson, "VISIDYN - Ett program för interaktiv analys av reglersystem," (VISIDYN - An interactive program for design of linear dynamic systems), November 1987.
- TFRT-5376 Hansson, M., and M. Andersson, "Reglering av kontinuerlig fettspaltningprocess," (Control of a continuous fat splitting process), December 1987.
- TFRT-5377 Nilsson, B., "Analys av turbinreglering i vattenkraftaggregat," (Analysis of the turbin governor in hydroelectric power plants), January 1988.
- TFRT-5378 Svensson, H., "Digital flickermeter," April 1988.
- TFRT-5379 Dahlberg, A., "Glapp och friktion i servosystem," (Backlash and friction in servo systems), May 1988.
- TFRT-5380 Johansson, U., "Scheduler till MIC-OS," (Scheduler for MIC-OS), June 1988.
- TFRT-5381 Schmidt, M., "Filhantering på externa massminnesmedier för litet processdatorsystem," (File handling for a small process control system), June 1988.

Report of Master Theses

TFRT-6016 Wittenmark, B., "Master theses in automatic control," December 1986.

Internal Reports

TFRT-7364 Brück, D., "Simplification of expressions using prolog," July 1987.

TFRT-7365 Denham, M. J., "Knowledge representation in systems modelling," August 1987.

TFRT-7366 Fredrick, D. K., "An introductory of a window-based environment for simnon on the Sun workstation," September 1987.

TFRT-7367 Brück, D. M., "Design and implementation of a graphical front-end," August 1987.

TFRT-7368 Åström, K. J., L. Neumann, and P. O. Gutman, "A comparison of robust and adaptive control," August 1987.

TFRT-7369 Kreutzer, W., "An exercise in system representations," September 1987.

TFRT-7370 Hang, C. C., and K. J. Åström, "Practical aspects of PID auto-tuners based on relay feedback," September 1987.

TFRT-7371 Hang, C. C., and K. J. Åström, "Refinements of the Ziegler-Nichols tuning formula for PID auto-tuners," October 1987.

TFRT-7372 Rundqwist, L., "Illustrations in \TeX documents," October 1987.

TFRT-7373 Johansson, R., M. Magnusson, and M. Åkesson, "Identification of human posture dynamics," November 1987.

TFRT-7374 Johansson, R., and E. Zettergren, "A smooth D/A-converter for robotic applications," January 1988.

TFRT-7375 Mattsson, S. E., and K. J. Åström, "The CACE project - Steering committee meeting 1987-11-25," January 1988.

- TFRT-7376 Wallenborg, A., and K. J. Åström, "Limit cycle oscillations in high performance robot drives," January 1988.
- TFRT-7377 Johansson, R., "Stochastic stability of direct adaptive control," January 1988.
- TFRT-7378 Akke, M., "Heffron-Phillips generatormodell," (Heffron-Phillips generator model), February 1988.
- TFRT-7379 Nilsson, B., "A small system-structuring system in scheme," February 1988.
- TFRT-7381 Åström, K. J., "Dominant pole placement design of PI regulators," February 1988.
- TFRT-7382 Lundh, M., "A TOOLBOX for discrete time design and on-line control," March 1988.
- TFRT-7383 Rundqwist, L., "Självinställande reglering av syrehalten i luftningsbassänger på Käppalaverket – Programdokumentation," (Self-tuning control of dissolved oxygen concentration in aerators at Käppala sewage works – Program documentation), March 1988.
- TFRT-7384 Johansson, R. (Ed.), "Processidentifiering. Projektarbete hösten 1987," (Process identification. Project work Autumn 1987), February 1988.
- TFRT-7385 Lundh, M., "Source code for TOOLBOX – Version 5.2," March 1988.
- TFRT-7386 Rundqwist, L., "Övningar och laborationer i Datorer i reglersystem," (Exercises and laboratories in Computers in control systems), April 1988.
- TFRT-7387 Kvist, P., and H. Ruijter, "An adaptive autopilot with feedforward compensation for wave disturbances applied to ship steering," April 1988.
- TFRT-7388 Rundqwist, L., "En laboration i direkt självinställande reglering," (A laboratory in direct self-tuning control), May 1988.
- TFRT-7389 Axelsson, J. P., "Experimental techniques and data analysis to determine baker's yeast ethanol dynamics," May 1988.

Reports

- TFRT-7390 Axelsson, J. P., "Characterizing the substrate control problem of ethanol monitored fed-batch yeast production," May 1988.
- TFRT-7391 Axelsson, J. P., "On the role of adaptive controllers in fed-batch yeast production," May 1988.
- TFRT-7392 Lundh, M., "Calculation of a real sorted Schur decomposition," June 1988.

Travel Report

- TFRT-8046 Wittenmark, B., "Travel report from Australia and China," August 1987.

E. Seminars at the Department

Seminars given at the department during the academic year 1987–1988, are summarized here. They are given both by the staff at the department and by invited lecturers.

1987

- July 2 Dean Frederick (Rensselaer Polytechnic Institute, New York): "Benchmark problems for CACSD."
- July 7 Per-Olof Gutman (ELOP, Israel): "Horowitz' design method in the general SISO case."
- July 9 Per-Olof Gutman (ELOP, Israel): "A new theorem, Horowitz cascade-SISO, sampled and nonminimum phase."
- July 9 Per-Olof Gutman (ELOP, Israel) and Karl Johan Åström: "Discussion seminar: Robust control (Horowitz' method, Pole placement, Kalman Filtering)."
- July 10 Per-Olof Gutman (ELOP, Israel): "Introduction to HOR-PAC."
- July 13 Bijoy Gosh (Washington University): "Overview of robust stabilization."
- July 14 Bijoy Gosh (Washington University): "AI methods in robust stabilization of time-varying systems."
- Aug 3 Dr. Chizeck (CASE Western Reserve University): "Control for movement of paralyzed muscles."
- Aug 5 Jean-Jacques Slotine (MIT): "Adaptive manipulator control: A case study."
- Aug 5 Thomas McAvoy (Maryland): "Discussion on the Foxboro "Exact" regulator."

- Aug 6 David Prett (Shell Development Company, Houston) "Computing in manufacturing."
- Aug 7 Odd Andreas Asbjørnsen (University of Maryland): "Systems engineering approach to modeling."
- Aug 7 David Prett (Shell Development Company): "Computing in manufacturing."
- Aug 7 Carlos Garcia (Shell Development Company): "Design of robust process controllers."
- Aug 25 C. C. Hang (National University of Singapore): "Adaptive control in the presence of deterministic load disturbances."
- Aug 26 Lars Rundqwist (Lund): "MacDraft figures in $\text{T}_{\text{E}}\text{X}$ documents."
- Aug 27 Jonas Fredenholm (Lund): "Primitive adaptive robot programs." MSc-thesis presentation.
- Aug 28 Lars Nielsen (Lund): "SeeHear."
- Sept 1 C. C. Hang (National University of Singapore): "Some experiences with PID Auto-tuners for process control."
- Sept 4 Sven Erik Mattsson (Lund): "CACE experiences."
- Sept 4 Bernt Nilsson (Lund): "Experiences of some modelling languages."
- Sept 4 Mats Andersson (Lund): "Object oriented system representation."
- Sept 4 Sven Erik Mattsson (Lund): "Plans for the CACE project."
- Sept 8 Robert Kosut (Stanford University, Calif.): "Robustness of adaptive control, I."
- Sept 8 Bengt Mårtensson (Lund): "Remarks on adaptive stabilization of first order nonlinear systems with finite escape time."
- Sept 10 C. C. Hang (National University of Singapore): "Dual-rate adaptive smith predictor."

1987

Seminars at the Department

- Sept 11 Claes Sjölin (Lund): "Expert system for fault diagnosis of a painting line at car industry." MSc-thesis presentation.
- Sept 11 Max L. Elliott (GTS-GRAL, Darmstadt): "FIGARO (a PHIGS implementation). Overview of PHIGS, PHIGS vs. GKS and other common standards, FIGARO on the IRIS 2400."
- Sept 11 Robert Kosut (Stanford University, Calif.): "Robustness of adaptive control, II."
- Sept 14 Johan Storm (Lund): "Analysis of resonance oscillations of the neutron flow in a BWR-core." MSc-thesis presentation.
- Sept 14 D. Rehak (Carnegie-Mellon Univ.): "Application of object oriented systems to robotics and finite element methods."
- Sept 17 Bo Wahlberg (Linköping University): "On the identification and approximation of linear systems."
- Sept 18 Robert Kosut (Stanford University, Calif.): "Estimation of model uncertainty."
- Sept 24 Steve DeWeerth (Caltech, Calif.): "Visual sensory motor feedback using analog VLSI."
- Sept 25 Björn Wittenmark (Lund): "A research report from Down Under."
- Oct 1 Federico Faggin (Synaptics, Calif.): "Neurocomputers."
- Oct 1 Per Bengtsson (Lund): "Search routine for optimization of the power in a wind power plant with variable speed."
- Oct 8 Robert Evans (Univ. of Newcastle, Australia): "Design of control system for a telescope."
- Oct 9 David Powell (Stanford): "Control of combustion engines."
- Oct 9 Tord Cedell (Lund): "Modelling of the industry robot system." MSc-thesis presentation.
- Oct 13 Bengt Mårtensson (Lund): "Hcopy2PS, curve compression and some new programs."
- Oct 15 John Cassidy (GE): "Control research at GE."

- Oct 16 Karl Johan Åström (Lund): "The MIT, Harvard, Brown – Center for Intelligent Control etc."
- Oct 29 Stephen Murphy (Rensselaer Polytechnic Institute, New York): "Experiments in adaptive robotics."
- Oct 30 Mats Lilja (Lund): "Controller design based on frequency responses."
- Oct 30 Bo Bernhardsson (Lund): "A dual controller."
- Oct 30 Kjell Gustafsson, Michael Lundh (Lund): "PI-control of the stepsize in numerical integration."
- Nov 3 Makoto Nagao (Kyoto University, Japan): "Image processing and character recognition."
- Nov 5 Karl-Erik Årzén (Lund): "Presentation and demonstration of G2."
- Nov 5 Chris Harris (Southampton University, UK): "Autonomous vehicle control using knowledge based fuzzy logic."
- Nov 5 Roy Leitch (Heriot-Watt University, Edinburgh, UK): "Qualitative modelling in industrial control."
- Nov 6 Karl-Erik Årzén (Lund): "Realization of expert system based feedback control." PhD defense, opponent Dr Roy Leitch (Heriot-Watt University, Edinburgh, UK).
- Nov 6 Chris Harris (University of Southampton, UK): "Multi-sensor data fusion – use of Dempster Schafer theory – reducing uncertainty."
- Nov 13 Leif Andersson (Lund): "SUN course."
- Nov 13 Björn Tyreus (DuPont, Newark, USA): "DuPont regulator structures."
- Nov 17 Andras Edelmayer (Hungarian Academy of Science, Budapest): "Real-time expert systems in discrete time stochastic adaptive control of manufacturing processes."

- Nov 19 Anders Rantzer (Lund): "On the minimal stabilizing feedback order (Preparation for CDC)."
- Nov 19 Rolf Johansson (Lund): "Identification of human posture dynamics."
- Nov 19 Magnus Akke (Lund): "Power oscillations in electric networks."
- Nov 19 Lars Nielsen (Lund): "SeeHear measurements."
- Nov 19 Lars Nielsen (Lund): "Experimental robot set-ups at Stanford."
- Nov 20 Håkan Svensson (Lund): "Digital flicker meter." MSc-thesis presentation.
- Nov 26 Stephen Murphy (Rensselaer Polytechnic Institute, New York): "Problems in coordination and force control."
- Nov 26 Ola Dahl (Lund): "Study of the Shin-McKay algorithm."
- Nov 26 Jan Peter Axelsson (Lund): "Progresses in the identification of baker's yeast ethanol dynamics."
- Nov 27 Leif Andersson (Lund): "SUN Course."
- Nov 30 Bengt Lennartsson (Chalmers, Gothenburg): "How efficient are our modern control methods?"
- Dec 1 Wolfgang Kreutzer (Univ. of Canterbury, New Zealand): "Tools and metaphors of AI-programming."
- Dec 3 Anders Lanser (KTH, Stockholm): "A survey of neural network models and neural computers."
- Dec 3 Anders Lanser (KTH, Stockholm): "A neural network model with probabilistic learning and complex nodes."
- Dec 4 Magnus Hansson and Magnus Andersson (Lund): "Control of a continuous fat splitting process." MSc-thesis presentation.

- Dec 11 Emil Granbom and Torsten Olsson (Lund): "VISIDYN – An interactive program for design of linear dynamic systems." MSc-thesis presentation.
- Dec 18 Thomas Gustafsson (Luleå Institute of Technology): "Control of cranes."
- Dec 18 Thomas Gustafsson (Luleå Institute of Technology): "Demonstration of REGSIM."
- Dec 29 Magnus Rimvall (ETH, Zürich): "Experiences of the IMPACT project."
- 1988**
- Jan 7 Wolfgang Kreutzer (Univ. of Canterbury, New Zealand): "Components of discrete event simulators and their implementation in Scheme."
- Jan 7 Wolfgang Kreutzer (Univ. of Canterbury, New Zealand) and others: "Discussion around CACE and discrete event simulation."
- Jan 15 David Hill (Univ. of Newcastle, Australia): "Power system stability and security."
- Jan 22 Mats Andersson (Lund): "Introduction to KEE."
- Jan 25 Peter Eltzer (Asea Brown Boveri): "ESPRIT-projektet "The GRADIENT" (Realtime-AI)."
- Jan 26 Peter Eltzer (Asea Brown Boveri): "Management of software projects."
- Feb 1 Rod Bell (Macquarie University, Australia): "Power station modelling and control."
- Feb 5 Kjell Gustafsson (Lund): "Modelling and synthesis of step-size control in numerical integration."
- Feb 5 Bo Nilsson (Lund): "Analysis of the turbin governor in hydroelectric power plants." MSc-thesis presentation.

- Feb 19 Rolf Syding (First Control AB, Västerås): "Firstcon Programming." A one-day course.
- March 16 Bo Bernhardsson and Jan Eric Larsson (Lund): "Colin Vout's Car Game."
- March 16 Bo Bernhardsson (Lund): "ARNE – Analys-Räkning Numera Elektroniskt." An expert system to solve the exams of the first course on one-dimensional analysis.
- March 16 Michael Lundh (Lund): "A polynomial calculator in PC-Scheme."
- March 16 Ola Dahl (Lund): "Generation of modular code from a Simmon model."
- March 16 Jan Eric Larsson (Lund): "MESS - A Minimal Expert System Shell."
- March 16 Karl Johan Åström (Lund): "System representations."
- March 16 Bernt Nilsson (Lund): "FourS (Small System Structuring System) in Scheme."
- March 16 Jan Eric Larsson (Lund): "An expert system for KRK." (Chess: King and Rook versus King).
- March 17 Rune Gustafsson (SICS): "Real-time system and AI."
- March 17 Sven Erik Mattsson, Karl-Erik Årzén, and Bernt Nilsson (Lund): "Our trip to USA."
- March 25 Bo Egardt (Asea, Västerås): "Life experiences as a PhD in industry."
- April 5 Per-Olof Gutman (ELOP, Israel): "Horowitz design 1."
- April 6 Per-Olof Gutman (ELOP, Israel): "Horowitz design 2."
- April 6 Sigurd Skogestad (NTH, Trondheim, Norway): "The μ -method."
- April 7 Sigurd Skogestad (NTH, Trondheim, Norway): "Control of distillation columns."

- April 7 Per-Olof Gutman (ELOP, Israel): "Robust adaptive control."
- April 8 Per-Olof Gutman (ELOP, Israel): "Tracking target with unknown process noise variance using an adaptive Kalman filter." Docent lecture.
- April 8 Leif Andersson (Lund): "Data communication."
- April 11 Howard Chizek (Case Western University, Ohio): "Control of functional neuromuscular stimulation systems for standing and locomotion in paraplegics."
- April 22 Rolf Johansson (Lund): "Petri nets."
- April 26 Rolf Johansson (Lund): "Grafcet."
- April 27 Henry Lymark och Torbjörn Holmqvist (Handikappinstitutet, Sweden): "Hand and arm prosthesises, and robot arms."
- April 29 Rolf Johansson (Lund): "Applications of Petri nets and Grafcet in the process industry."
- May 4 P. C. Parks (Mathematics Group, RMCS, Shrivenham, UK): "Convergence properties of associative memory storage for learning control systems."
- May 6 Douglas Birdwell (University of Tennessee, USA): "An overview of the LQG/LTR, controller design methodology."
- May 10 Douglas Birdwell (University of Tennessee, USA): "The influence of an expert system on the evolution of a design environment."
- May 17 Douglas Birdwell (University of Tennessee, USA): "The structure of the CASCADE design environment."
- May 27 Douglas Birdwell (University of Tennessee, USA): "Search for model structure using process databases."
- May 27 Måns Magnusson (Lunds Lasarett): "Characteristic parameters of anterior-posterior body sway during stance in normal subjects."

- May 31 Kjell Gustafsson (Lund): "Stepsize control in ODE-solvers – Analysis and synthesis." Lic Tech dissertation seminar. Opponent Torkel Glad (Linköping University).
- June 2 Tom McAvoy (University of Maryland): "DICODE – a distillation column expert system design package."
- June 2 D. J. Collins (Dept of Navy, London): "Application of eigenstructure, Assignment of self reconfiguring, Aircraft MIMO controllers."
- June 3 Douglas Birdwell (University of Tennessee, USA): "Search for model structure using process databases."
- June 7 Anders Dahlberg (Lund): "Backlash and friction in servosystems." MSc-thesis presentation.
- June 10 Lars Rundqwist (Lund): "Experiences of self-tuning control of the activated sludge process."
- June 14 Stephen Murphy (Rensselaer Polytechnic Institute, New York): "Control of two robots in Cartesian space."
- June 16 Mikael Schmidt (Lund): "File handling for a small process control system." MSc-thesis presentation.
- June 17 Douglas Birdwell (University of Tennessee, USA): "Teaching with the CASCADE design environment."
- June 21 Douglas Birdwell (University of Tennessee, USA): "Stochastic decision theory."
- June 27 Ola Söderström (Lund): "Curve profile generator for packeting machines." MSc-thesis presentation.

F. Lectures by the staff

1987

- July 1 Karl Johan Åström: "Stochastic control theory," Invited plenary lecture, 1st Int Congress of Industrial and Applied Mathematics (ICIAM '87), Paris, France.
- Aug 3 Lars Nielsen: "SeeHear," The 1987 Stockholm Workshop on Computational Vision, Stockholm, Sweden.
- Sept 28 Karl Johan Åström: "Advanced control methods – Survey and assessment of possibilities," 13th Annual Advanced Control Conference, Purdue University, West Lafayette, Indiana.
- Sept 30 Karl Johan Åström: "Recent advances in theory and practice of adaptive control," School of Mechanical Engineering, Purdue University, West Lafayette, Indiana.
- Oct 6 Karl Johan Åström: "Intelligent control," Center for Intelligent Systems, MIT, Cambridge, Massachusetts.
- Oct 19–20 Karl Johan Åström: Minicourse on Adaptive Control: 1. "Algorithms," 2. "Stability," 3. "Convergence," and 4. "Robustness," University of Texas, Austin, USA.
- Oct 20 Lars Nielsen: "SeeHear – A prosthesis for the blind," Computer Science, Caltech, California, USA.
- Oct 22 Karl Johan Åström: "Adaptive control systems," Texas Systems Day, Texas A&M University, Texas, USA.
- Oct 22 Lars Nielsen: "SeeHear – New measurements," Physics of computation group, Caltech, California, USA.
- Nov 23 Karl Johan Åström: "The role of an AI in process control," Shell Seminar on the Horizon Plant, Centre de Recherche de Grand-Couronne, Rouen, France.

- Nov 23 Lars Nielsen: "SeeHear – En protes för blinda," (SeeHear – A prosthesis for the blind), Öronkliniken, Lunds Lasarett, Lund, Sweden.
- Nov 27 Lars Nielsen: "Control based on computer vision," Linköping Institute of Technology, Linköping, Sweden.
- Dec 2 Lars Rundqwist: "Self-tuning control of the dissolved oxygen concentration in activated sludge systems," Danish Automation Society Workshop on Quality Assurance in Wastewater Treatment, DTH, Lyngby, Denmark.
- Dec 16 Karl-Erik Årzén: "Expert control," ABB Västerås, Sweden.
- 1988
- Jan 19 Karl-Erik Årzén: "Knowledge-based systems in the design and implementation of control systems – Activities at the Department of Automatic Control, Lund," INRIA conference "Systèmes à Base de Connaissances pour la CAO en Automatique", INRIA-Rocquencourt, France.
- Jan 27 Karl Johan Åström: "An introduction to modern control techniques," First Philips Conference on Applications of Systems & Control Theory, Brussels, Belgium.
- Jan 28 Karl Johan Åström: "Adaptive feedback control, I & II," First Philips Conference on Applications of Systems & Control Theory, Brussels, Belgium.
- Jan 29 Lars Nielsen: "Robotstyrning," (Robot control), Robotsymposium '88, Idéon, Lund, Sweden.
- Feb 10 Rolf Johansson: "Teori för adaptiva reglersystem," (Theory for adaptive control systems) SIK, Symposium on Process Control for the Food Industry, Gothenburg, Sweden.
- Feb 29 Karl-Erik Årzén: "Expert Control," Foxboro Company, Foxboro, Massachusetts, USA.
- Feb 29 Sven Erik Mattsson: "The CACE Project – An overview," and "Hibliz – A simulator using hierarchical block diagrams," Foxboro Company, Foxboro, Massachusetts, USA.

- March 3 Karl Johan Åström: "Behöver en kemist veta något om reglering?," (Does a chemist need to know anything about control?), Kemiska Föreningen i Lund, Chemical Center, University of Lund, Sweden.
- March 10 Lars Nielsen: "Visuell styrning," (Visual control) SSAB Symposium, Swedish IAPR Symposium on Image Analysis, Lund Institute of Technology, Lund, Sweden.
- March 11 Ola Dahl: "Ash line control," SSAB Symposium, Swedish IAPR Symposium on Image Analysis, Lund Institute of Technology, Sweden.
- March 11 Karl-Erik Årzén: "Expert system applications in process control," STFI Course, Dundret, Gällivare, Sweden.
- March 16 Sven Erik Mattsson: "The CACE Project – An overview," "Hibliz – A simulator using hierarchical block diagrams," and "An expert system interface for Idpac," Department of Information Processing, University of Umeå, Umeå, Sweden.
- March 24 Jan Eric Larsson: "On expert systems," Department of Philosophy, University of Lund, Sweden.
- March 29 Karl-Erik Årzén: "Expert system application in process control," Enea Data, Malmö, Sweden.
- March 31 Jan Peter Axelsson: "Experimental techniques and data analysis to determine baker's yeast ethanol dynamics," ANABIOTEC'88, 2nd International symposium on analytical methods and problems in biotechnology, Noordwijkerhout, The Netherlands.
- April 14 Anders Wallenborg: "Limit cycle oscillations in high performance robot drives," Int Conference Control '88, University of Oxford, UK.
- April 19 Karl Johan Åström: "Impact of information Technology on industrial production," IVA New Sweden seminar on Information and Communication Technology – Tools for the Future, Chicago, USA.

- April 19 Per Persson: "Expert systems interface for interactive programs," Enea Data, Malmö, Sweden.
- April 26 Karl-Erik Årzén: "Expert Control," Intelligent Automation Laboratory, Department of Electrical and Electronics Engineering, Heriot-Watt University Edinburgh, Scotland.
- April 26 Sven Erik Mattsson: "The CACE Project – An overview," Intelligent Automation Laboratory, Department of Electrical and Electronics Engineering, Heriot-Watt University, Edinburgh, Scotland.
- May 5 Karl Johan Åström: Minicourse on Adaptive control theory: 1. "Automatic tuning of simple regulators," University of Oxford, UK.
- May 10 Björn Wittenmark: "Implementation and application of adaptive control," Catholic University of Louvain de Neuf, Belgium.
- May 12 Karl Johan Åström: Minicourse on Adaptive control theory: 2. "Computer aided control engineering," University of Oxford, UK.
- May 18 Karl Johan Åström: Minicourse on Adaptive control theory: 3. "Adaptive control algorithms," University of Oxford, UK.
- May 18 Rolf Johansson: "Rationella metoder för styrteknik och sekvensstyrning," Reglermöte '88 (Control Meeting '88), Uppsala, Sweden.
- May 19 Karl-Erik Årzén: "Expert system applications in process control – A survey," (Expertsystemtillämpningar inom processreglering: En översikt), Reglermöte '88 (Control Meeting '88), Uppsala, Sweden.
- May 20 Karl-Erik Årzén: "Expert system applications in process control – A survey," OVO Elektronik, Lund, Sweden.
- May 25 Jan Eric Larsson: "Regelbaser för slutspel i schack," (Rule bases for chess endings), SAIS '88 Workshop, University of Umeå, Sweden.

- May 26 Karl Johan Åström: Minicourse on Adaptive control theory: 4. "Stability of adaptive regulators," University of Oxford, UK.
- May 26 Bo Bernhardsson: "Dual control of a first order dynamical system," The Nordic Section of SIAM Meeting on Industrial and Applied Mathematics: New Methods and Techniques Useful to Industry and Science, University of Bergen, Norway.
- May 26 Kjell Gustafsson: "Analysis and synthesis of stepsize control in numerical integration," The Nordic Section of SIAM Meeting on Industrial and Applied Mathematics: New Methods and Techniques Useful to Industry and Science, University of Bergen, Norway.
- May 27 Karl Johan Åström: "Towards intelligent control," Douglas Holder lecture at University College, University of Oxford, UK.
- May 30 Karl Johan Åström: "Autotuning, adaptation and expert system," Course on Application of Advanced Control in the Chemical Process Industries, DTH, Lyngby, Denmark.
- May 31 Rolf Johansson: "Determination of characteristic parameters of human posture dynamics," 9th Int Symposium on Postural and Gait Research, Marseille, France.
- May 31 Rolf Johansson: "Characteristic parameters of anterior-posterior sway during stance in normal subjects," 9th Int. Symp. on Postural and Gait Research Marseille, France.
- June 2 Karl Johan Åström: Minicourse on Adaptive control theory: 5. "Tools for convergence analysis," University of Oxford, UK.
- June 9 Karl Johan Åström: Minicourse on Adaptive control theory: 6. "Convergence analysis of adaptive algorithms," University of Oxford, UK.

- June 10 Karl Johan Åström: "Stability of model-reference adaptive control systems in the presence of unmodelled dynamics," Department of Electrical Engineering, Imperial College, London, UK.
- June 14 Karl Johan Åström: "Adaptation auto-tuning and intelligent control," Tutorial Workshop on Some Aspects of Intelligent Control, American Control Conference, Atlanta, Georgia, USA.
- June 14 Rolf Johansson: "Determination of characteristic parameters of human posture dynamics," Bårány Society Int. Meeting in Uppsala, Sweden.
- June 15 Karl Johan Åström: "Towards intelligent control," invited plenary lecture at American Control Conference, Atlanta, Georgia, USA.
- June 15 Rolf Johansson: "Dynamic properties of anterior-posterior sway during stance in normal subjects," Bårány Society Int. Meeting in Uppsala, Sweden.
- June 16 Rolf Johansson: "Human posture performance parameters," Post Barany Meeting, Lund, Sweden.
- June 17 Karl Johan Åström: "Robust and adaptive pole-placement," American Control Conference, Atlanta, Georgia, USA.
- June 21 Karl Johan Åström: "Practical experiences of adaptive control," University of Sussex, UK.
- June 21 Björn Wittenmark: "Implementation issues in adaptive control," Workshop on Adaptive Control Strategies for Industrial Use, Banff Canada.
- June 24 Karl Johan Åström: Minicourse on Adaptive control theory: 7. "Robustness of adaptive control," University of Oxford, UK.

G. Travels

The "10th IFAC World Congress on Automatic Control" was held in Munich, 27–31 July 1987. Because of the closeness, an effort was made to let many graduate students participate. It was an excellent opportunity to meet researchers personally and to get a good overview of the field. The following persons attended: Magnus Akke, Mats Andersson, Karl Johan Åström, Jan Peter Axelsson, Ola Dahl, Kjell Gustafsson, Per Hagander, Ulf Holmberg, Mats Lilja, Michael Lundh, Sven Erik Mattsson, Per Olof Olsson, Anders Wallenborg, and Björn Wittenmark.

In June 1988 a congress for secretaries was held in Umeå. About 800 university secretaries from all over Sweden attended. Several subjects were discussed at the congress. Some subjects were: The secretary of tomorrow, The woman's way to independence and equality, The labour market from a female point of view, Career of the secretary, Economy, Preservation of terminology, Stress, Working environment and computers, and Computer screens – radiation and skin affection. Eva Dagnegård, Britt-Marie Mårtensson, Eva Schildt, and Agneta Tuszynski attended from the Department.

Karl-Erik Årzén participated in the "First European Meeting on Cognitive Science Approaches to Process Control" held in Marcoussis, France October 19–21 1987. In January 18–20 1988 he was invited to the "INRIA Workshop on Knowledge-based Systems for Computer-aided Design of Control Systems" in Rocquencourt, France.

As a part of the IT4 project "Knowledge-based real-time control systems" he visited Denmark on 15–16 February 1988 together with Karl Johan Åström and Per Persson (Automatic Control), Claes Ryttoft and Kent Bladh (ABB), Börje Rosenberg (Satt Control), and Mats Peterson (TeleLOGIC). On February 15 they visited Professor Morten Lindh at the Servolaboratory, DTH Lyngby and the company Søren T. Lyngsø in Hørsholm. On February 16 they visited the company F.L. Schmidt in Copenhagen.

On 21 February – 4 March he visited USA together with Sven Erik Mattsson and Bernt Nilsson. On 22–26 February they attended a course

Jan Peter Axelsson participated in the IFAC World Congress in Munich, August 1987. On the way back to Lund he made a visit at department of Biotechnology at ETH, Zürich. He discussed mathematical modelling of baker's yeast with dr Sonnleitner and his PhD student, Strässle. In April 1988 he participated in a biotechnical conference "ANABIOTEC '88" in Holland, where he presented a paper.

Bo Bernhardsson attended the "Nordic Section of SIAM Meeting on Industrial and Applied Mathematics" held in May in Bergen, Norway, where he also presented a paper.

Dag Brück attended "C++ and Object-oriented Programming," a one-day seminar in Stockholm, 25 May 1988. It was given by Dr Bjarne Stroustrup, AT&T Bell Labs, Murray Hill, USA. Dr Stroustrup is the designer and implementer of C++.

Ola Dahl participated in the IFAC World Congress in Munich, July 1987. He visited the Swedish Board for Technical Development (STU), Stockholm, in December, where he attended a seminar about 1. The STU Research Program and 2. Adaptive Controlled Industrial Robots.

Kjell Gustafsson attended the "10th IFAC World Congress on Automatic Control" held in Munich, Federal Public of Germany, on 27–31 of July, 1987. In May 26–27, 1988, Gustafsson participated in the "The Nordic Section of SIAM Meeting on Industrial and Applied Mathematics" held in Bergen, Norway, where he also presented a paper.

Per Hagander participated in the IFAC World Congress in Munich, July 1987, and in the "Workshop on Developments in Chemical Process Control" at DTH, Denmark, August 1987. In May 1988 he was external examiner of a Lic Tech thesis (Karin Ståhl) at Linköping Institute of Technology, Sweden.

Rolf Johansson attended the workshop in automatic control, "Reglermöte 88", in Uppsala, May 1988. In May he attended at the conference "9th Int. Symposium on Postural and Gait Research" in Marseille, France. He also attended the "Bárány Society Int. Meeting" in Uppsala, June 1988.

on the real-time expert system shell G2 at Gensym, Cambridge MA. On 29 February they visited the Foxboro Company, Foxboro MA. Årzén then went to New York where he visited Michael Stock at Artificial Intelligence Technologies on 1 March. On 2 March he visited Dr Milliken at IBM Yorktown Heights. He then rejoined with Sven Erik Mattsson and Bernt Nilsson to visit the Systems Research Center at the University of Maryland on 3–4 March. Among others they met John Baras, P.S. Krishnaprasad, William Levine, André Tits, Michael Fan, Thomas McAvoy, Odd Asbjørnsen, and Mohammed Modarres.

Årzén visited UK on 25–28 April 1988. On 25 April he and Sven Erik Mattsson visited Dr Roy Leitch, Intelligent Automation Laboratory, Department of Electrical and Electronics Engineering, Heriot-Watt University, Edinburgh Scotland. On April 26th Claes Ryttoft and Anders Åberg (ABB), Börje Rosenberg (SattControl), and David Lundberg (TeleLOGIC) from the IT4 project "Knowledge-based real-time control systems" joined them. They then went to London and visited PA Computers and Telecommunications on April 27. On 28 April the group split and Årzén joined the group which visited SIRA Ltd, Chislehurst. On May 4 Karl-Erik Årzén together with Claes Ryttoft, Börje Rosenberg, and David Lundberg visited CRI in Denmark. They met Åge Jonasen. On 18–19 May he gave a presentation at the "Control Meeting '88" (Reglermöte '88) in Uppsala, Sweden.

Karl Johan Åström participated in the ICIAM conference, Paris, in July 1987 and in the "IFAC Triennial International World Congress," Munich, in August. In September–October he went to USA, where he participated in the "13th Annual Advanced Control Conference" at Purdue University. He also visited the Center for Intelligent Systems at MIT, Cambridge, and the University of Texas at Austin. In November he visited l'Institut National Polytechnique de Grenoble, France, Centre de Recherche de Grand-Couronne, Rouen, France.

In January 1988 he participated in the "First Philips Conference on Applications of Systems & Control Theory," Brussels, Belgium. In April he participated in the "International Conference Control '88" at the University of Oxford, UK, and in the "IVA New Sweden Seminar on Information and Communication Technology" in Chicago, USA. In June he participated in the "American Control Conference" held in Atlanta, Georgia, USA, and visited University of Sussex, UK. During May–June 1988 he was visiting fellow at Oxford University, UK.

Sven Erik Mattsson attended the "10th IFAC World Congress on Automatic Control" held 27–31 July 1987, in Munich, Germany. He participated in the meeting of the IFAC Working Group on 'Guidelines for CACSD Software'.

On 22–26 February, 1988, he attended together with Bernt Nilsson and Karl-Erik Årzén a course on the real-time expert system shell G2 at Gensym, Cambridge, Massachusetts, USA. On 29 February they visited the Foxboro Company, Foxboro, Massachusetts. Mattsson then went to Pittsburgh to visit Carnegie Mellon University on 1–2 March. He met Dr Art Westerberg, Chemical Department, Dr Ingemar Hulthage, the Robotics Institute and Marc Bodson at the Electrical Department. He then rejoined with Bernt Nilsson and Karl-Erik Årzén to visit the Systems Research Center at the University of Maryland on 3–4 March. Among others they met John Baras, P. S. Krishnaprasad, William Levine, André Tits, Michael Fan, Thomas McAvoy and Odd Asbjørnsen.

On 26 April he and Karl-Erik Årzén visited Dr Roy Leitch, Intelligent Automation Laboratory, Department of Electrical Engineering, Heriot-Watt University, Edinburgh, Scotland, on 27 April. As a part of the IT4 project "Knowledge based systems for process control" they visited together with Claes Rytøft (ABB), Anders Åberg (ABB), Börje Rosenberg (SattControl), Lars Pernebo (SattControl) and David Lundberg (Telelogic) the Heriot-Watt University. They visited the Department of Electrical Engineering, the AI group and the Institute for applied AI (AIAI). They then went to London and visited PA Computers and Telecommunications on April 28. On 29 April the group split and Mattsson joined the group which visited Cambridge Consultants Limited, Cambridge.

Lars Nielsen participated in the "1987 Stockholm Workshop on Computational Vision" on August 3–6, where he gave an invited talk. On October 14–27 he visited the analog VLSI and neural systems group headed by Carver Mead at Caltech, USA. The joint projects on neuron based motor control and the SeeHear system were continued. A number of successful experiments were conducted on the SeeHear chip. He also made a short trip to Stanford and visited the labs of Franklin, Powell and Cannon on October 23.

He was invited to Linköping Institute of Technology on November 27. There he gave a seminar on control based on computer vision. In January 1988 Lars Nielsen visited Tampere Institute of Technology, Finland, to see their efforts in the robot ping-pong player contest. On May 19-20

he participated in a seminar about a possible major effort in the area of neural networks. The seminar was organized by STU and held in Uppsala, Sweden.

Bernt Nilsson participated in the IFAC World Congress in Munich, July 1987. In February 1988 he went to USA. He visited George Stephanopoulos and his group at MIT, Cambridge, Massachusetts, and the Systems Research Center at the University of Maryland. Together with Sven Erik Mattsson and Karl-Erik Årzén he attended a course on the real-time expert system shell G2 at Gensym, Cambridge, Massachusetts. In March Bernt Nilsson visited Columbia University, New York, where he presented his work.

Lars Rundqwist visited the Technical University of Denmark, Lyngby, Denmark in December 1987, where he gave a lecture at the Danish Automation Society Workshop on Quality Assurance in Wastewater Treatment.

Tomas Schönthal attended "C++ and Object-oriented Programming," a one-day seminar in Stockholm, 25 May 1988. It was given by Dr Bjarne Stroustrup, AT&T Bell Labs, Murray Hill, USA. Dr Stroustrup is the designer and implementer of C++.

Björn Wittenmark has participated in the following conferences: "10th IFAC World Congress" held in Munich 27–31 July 1987, "Conference on Decision and Control" in Los Angeles, California, 9–11 December 1987, "Reglermöte '88" held in Uppsala, Sweden, 17–19 May 1988, "American Control Conference" held in Atlanta, Georgia, 15–17 June 1988, and "Workshop on Adaptive Control Strategies for Industrial Use" held in Banff, Canada, 20–22 June 1988. He has also visited Catholic University of Louvain, Belgium, and DTH in Denmark.

