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ACTIVITY REPORT
1979 - 1980

PER HAGANDE

Department of Automatic Control, Lund Institute of Technology
ACTIVITY REPORT

1979 - 1980

Per Hagander
The report surveys the activities at the Department of Automatic Control, Lund Institute of Technology, during the academic year 1979-80. At the civilingenjör level (≈ MS) seven different courses are given on regular basis. About 400 students have participated during the year. Also 13 MS-theses and 1 PhD-thesis have been completed.

The major areas of research have been adaptive control, robustness, system identification, and computer aided design of control systems.
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1. INTRODUCTION

The activities in the academic year 1979/80 are reported here. During the year one project was finished, computer aided design, and a new one started, software for implementation of control systems. The latter is described in some detail, while for the other projects it is referred to previous Annual Reports and to the reports listed in the Appendices.

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. The address is:

University Library 2
Box 1010
S-221 03 Lund, Sweden

We want to thank our sponsors, The Swedish Board of Technical Development (STU), The Swedish Institute of Applied Mathematics (ITM), The Research Institute of National Defense (FOA), The Swedish Council for Planning and Coordination of Research (FRN), and Sydkraft AB for their support to our projects.
2. EDUCATION

Two new undergraduate courses have been given: Principles of automatic control and Computers in control systems II.

**Principles of automatic control**

This is a new course that has been given for chemical engineers. For the moment the course is taken by students specializing in food engineering. The other chemical engineering students are taking the course Automatic control for chemical engineers. The intention is that the new course is going to be the basic course for all chemical engineers. Those specializing in chemical equipment and processes should then have the possibility to get a deeper knowledge in automatic control. The emphases of the new course are to introduce the concepts of dynamic systems, mathematical models, feedback, and simple controllers. The intention is to give the students a feeling for what can be done with automatic control.

**Undergraduate course in real-time computing**

The course Computers in control systems I has been given since 1974. It contains both the hardware and software and is given also for chemical and mechanical engineers. Starting in 1979 a new elective course, Computers in control systems II, has been given for about 55 students per year with a solid background in electronics and computers. This course has an emphasis on software and especially concurrent programming. Pascal is used as the basic language, and exercises are done on a LSI-11 system. The course is very much influenced by the book Brinch-Hansen: Operating system principles. Data structures and linked lists are introduced and the problems of concurrency are described together with the tools for synchronization, such as critical regions, semaphores, and monitors.

Practical programming exercises successively prepare for quite an extensive project work.

The project corresponds to about 1 week full time work and is done in a group of four students. The task has been to construct a DDC program package. The basic structure of the package is given. The desired operator commands and control algorithms are defined. The students have to construct suitable data structures and write operator communication as well as control algorithms. The DDC program package is tried out on laboratory processes.
3. RESEARCH

The major research areas have been described in previous activity reports. The project Computer aided design of control systems was completed during the year. A feasibility study on a new project "Languages for implementation of control system" was started. This project is described below.

Software for implementation of control systems

Since it becomes more and more common to use computers as components in control systems, it is important to have powerful software tools. The opinion generally held is that the tools commonly used today are inefficient and difficult to use and do not give a reliable product. Moreover it is commonly understood that it is necessary to use abstract languages when writing concurrent programs.

In 1978 it was recognized at the department that it was necessary to get experiences from these new languages for concurrent programming. At that time only Concurrent Pascal was available. It was decided to try to implement Concurrent Pascal on LSI-11. It turned out to be possible and gave us a profound insight in the problem.

Together with the National Defence Research Institute (FOA) the department participated in Ada Test and Evaluation, Phase III. This cooperation with FOA will be continued in a project to study the quantitative and qualitative properties of Ada when implementing control systems and to compare these with for example Concurrent Pascal, Portal, Modula-2 and Pascal/D80. The study will be carried through as a project to develop the software for a control system. The system to be controlled is a 3 MW horizontal axis wind energy conversion system, that will be built by Karlskronavarvet AB in cooperation with Hamilton Standard.

The feasibility study "Languages for implementation of control systems" has been performed during the year. The presently used aids for implementation of control systems have been studied, such as real-time operating systems, DDC-packages, programmable controllers, real-time Basic, modern languages for concurrent programming and micro processor based controllers with fixed programs. Special attention has been devoted to study the different concepts and how they relate to each other.

A simple language for description of control systems has been developed as a pilot project. It is highly interactive. The control algorithms can be edited on a text screen. The replacement of a control algorithm then takes place between two interpretations (the algorithms are stored in an
intermediate form, similar to P-code, and interpreted).

Another pilot project was the construction of a small operating system (kernel) to be used together with Pascal. It gives the possibility to make procedures behave as concurrent processes. The kernel also handles semaphores and interrupts.

4. LABORATORY

New laboratory computer system

The PDP 15 computer system at the department has been in use since 1970. A total of 47 500 CPU hours was logged on the computer on June 30, 1980. The department has got investment funding for a replacement system. A thorough evaluation was done, and as a result a VAX11/780 was ordered. The system will be delivered in the fall of 1980. It is going to be used in the research for interactive computing, hierarchical control together with the existing LSI-11 systems, and for real time control tasks.
APPENDIX A - LIST OF PERSONNEL

Professor

Karl Johan Aström

University lecturers (Universitetslektorer)

Gustaf Olsson
Björn Wittenmark

Research assistant (Forskarassistent)

Per Hagander (Docent)

Research engineers (Forskningsingenjörer)

Leif Andersson
Bo Egardt (PhD; in USA 1980)
Hilding Elmqvist (PhD)
Tommy Essebo (programmer)
Ivar Gustavsson (PhD) until Dec 1980
Per Molander (PhD 1979)
Ann-Britt Nilsson (on leave 1980)
Lars Pernebo (PhD)
Thomas Schönthal (programmer)
Jan Sternby (PhD) until April 1980
Johan Wieslander (PhD) until Febr 1980

Teaching assistants (Assistenter)

Per-Olof Gutman (PhD candidate)
Tore Hägglund (PhD candidate)
Rolf Johansson (PhD candidate)
Matz Lenells (PhD candidate)
Carl Fredrik Mannerfelt (PhD candidate)
Sven Erik Mattsson (PhD candidate)
Lars Nielsen (PhD candidate)

Laboratory engineer (Laboratorieingenjör)

Rolf Braun
Visiting scientists (Gästforskare)

Jean Nyquist (Sept 79 - June 80)
University of Michigan, Ann Arbor, Michigan, USA

Zhou Zhaoying (from Sept 1979)
Tsiaoghua University, Peking, China

Jin Shaoning (from Sept 1979)
South China Institute of Technology, Canton, China

Technical drawings (Tekniskt biträde)

Britt-Marie Carlsson

Secretaries (Sekreterare)

Eva Schildt
Eva Dagnegård (half time)

Typist (Skrivhjälp)

Bert Sjögren
APPENDIX B - PUBLISHED PAPERS AND CONFERENCE CONTRIBUTIONS


Elmqquist H: Manipulation of continuous models based on equations to assignment statements. IBACS Congress/Simulation of Systems, Sorrento, Italy, Sept 1979.


Wittenmark B, Bar-Shalom Y: Model validation from estimated closed loop performance. 5th IFAC Symposium on System Parameter Estimation, Darmstadt, Germany, Sep 1979.

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


FINAL REPORTS


ACTIVITY REPORTS


MASTER THESES


Olsson R: Modellering och simulering av synkrongeneratordynamik (Modelling and simulation of synchronous generator dynamics). June 1980.

REPORTS OF MASTER THESES


INTERNAL REPORTS


| TFRT-7185  | Wittenmark B: Regelproblem inom livsmedels-industrin (Control problems in the food-processing industries). Jan 1980. |
TRAVEL REPORTS


APPENDIX D - COURSES AND SEMINARS AT THE DEPARTMENT

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

**Undergraduate courses**
- Linear systems (Reglerteknik AK)
- Principles of automatic control (Reglerteknikens grunder)
- Automatic Control theory for chemical engineers (Reglerteknik MK)
- Nonlinear and sampled data systems (Reglerteknik FK)
- Systems engineering (Systemteknik)
- Computers in control systems I (Datorer i reglerteknik I)
- Computers in control systems II (Datorer i reglerteknik II)

**PhD Courses**
The following courses have been given:
- Optimal control (P Hagander)
- Linear system theory (B Wittenmark)
- Stochastic control theory (B Wittenmark, P Hagander)
- Biomedical systems (P Hagander)
- Modern languages for process control (L Andersson, H Elmqvist, S E Mattsson)
- Current topics in stability theory (P Molander)

**Seminars**
1979

Sep 5  E Irving (France): Improving power network stability with adaptive generator control.

Sep 6  Prof A Pearson (Brown Univ): System identification and signal estimation via a finite time equation error method.

Sep 7  A Pearson: Finite horizon time regulators for linear systems.

Sep 19 P Gawthrope (Oxford): Self-tuning control.

Sep 19 Prof J C Willems (Groningen): Almost (A+B)-invariant subspace.

Sep 20  J C Willems: Dissipative dynamical systems.
Oct 4  Prof P Caines (Harvard Univ): Non-stationary linear systems identification from cross-sectional data.

Oct 5  P Caines: Recent results in adaptive control.

Oct 5  H Austin Spaing (General Electric): Discussion on multivariable control.

Oct 9  T L Steding (Systems Control): A unified approach to operations scheduling in electric power systems.


Oct 16  L Olbjer (Mathematical Statistics, Lund): Convergence proof for STR.


Nov 30  Reglerteknik inom livsmedelsindustrin (Control problems in the food-processing industries). Kontaktdag.

1980

Jan 15  I Svensson (SMT Pullmax): Datorstyrning av verktygsmaskiner (Computer machine tool control).

Feb 8  H Skoog (ASEA): Industrirobotar och deras styrning (Industrial robots and their control).


March 18  J Sternby: Adaptive control of extremum systems.

May 13  G Cook (Univ of Virginia): Minimum noise aircraft landing trajectory.
May 28  L Radoune (Rabat, Maroc): Automatic control in Rabat.

May 30  A Sundström and G Olsson: Datakraft vid LU inför 80-talet (Computing power at Lund University during the 80's).


External courses

I. Computers and society (Datakraften i samhället). Basic course in computer science for journalists, financed by the Swedish Council for Planning and Coordination of Research (Forskningsrådsnämnden). January 28-29, 1980. Coordinator P-O Gutman. Contents:

1. P-O Gutman: Computer architecture.


4. J Wieslander: Automatic control and computers in industry today and in the future.

5. P Ragnarsson (Malmö Museum of Technology): Perspective on the impact of computers on society.


II. Simulation of dynamical systems. May 5-6, 1980.
Contents:


3. S Bergman (Sydkraft AB, Malmö): Modelling, simulation and identification of a measurement system in a nuclear power plant.


5. G Olsson: Simulation of wastewater treatment plants.


APPENDIX E - LECTURES BY THE STAFF

1979

July 16
Elmqvist H: Dymola - A structured model language for large continuous systems. Summer Computer Simulation Conference, Toronto, Canada.

Aug 1-6
Pernebo L: Algebraic control theory for linear multivariable systems. A series of four lectures at Price University, Houston, Texas, USA.

Aug 23
Aström K J: Self-tuning regulators - design principles and applications. Int Workshop on Applications of Adaptive Control, Yale University, New Haven, Conn, USA.

Aug 27
Aström K J: Adaptive control. Foxboro, Massachusetts, USA.

Aug 27
Aström K J: Applications of adaptive control. Du Pont, Wilmington, Delaware, USA.

Sep 6
Pernebo L: Some questions in multivariable control. Yale University, New Haven, Connecticut, USA.

Sep 7

Sep 10

Sep 13
Olsson G: Modeling and control of the activated sludge process. Invited paper, American Chemical Soc, Washington DC, USA.

Sep 18
Olsson G: Some new results on dissolved oxygen profile control. Metropolitan Sanitary District of Greater Chicago, Chicago, USA.

Sep 20
Pernebo L: Algebraic design theory for linear multivariable systems. University of Toronto, Toronto, Ontario, Canada.

Sep 21
Hagander P: Modeller för cellcykelkinetik och deras tillämpning på tumörterapi (Models for the cell cycle kinetics and their application in tumor therapy), Dept of Radiophysics, Lund, Sweden.
Sep 24 Elmqvist H: Manipulation of continuous models based on equations to assignment statements. IMACS Congress, Sorrento, Italy.

Sep 24 Aström K J: Maximum likelihood and prediction error methods. 5th IFAC Symp on Identification and System Parameter Estimation, Darmstadt, Germany.

Sep 25 Aström K J and Källström C G: Experiences of system identification applied to ship steering dynamics. 5th IFAC Symp on Identification and System Parameter Estimation, Darmstadt, Germany.

Sep 25 Wittenmark B: Model validation from estimated closed loop performance. IFAC Symp on Identification and System Parameter Estimation, Darmstadt, Germany.


Dec 4 Wittenmark B: Self-tuning PID-controllers based on pole placement. Brown University, Providence, USA.

Dec 6 Wittenmark B: Self-tuning PID-controllers based on pole placement. University of Connecticut, Storrs, USA.

Dec 11 Hagander P: Stokastiska flödessystem och cellcykler (Stochastic flow systems and cell cycles), Department of Electrical Engineering, Linköping, Sweden.

1980


March 4  Wittenmark B: Comparison of recursive identification methods. LEESA, Rabat, Marocko.

March 5  Wittenmark B: Self-tuning algorithms for control prediction and smoothing. LEESA, Rabat, Marocko.

March 6-7  Elmqvist H: 1. Syntax driven input and output. 2. Parametric types in Pascal. 3. Research and development at Automatic Control in Lund. Three lectures at Landis & Gyr, Zug, Switzerland.

March 10-14  Åström K J: Modelbildung - Identification - Adaptive Systeme (Three lectures on modeling, identification and adaptive control). Tagung Über Regelungstheorie, Mathematisches Forschungsinstitut, Oberwolfach, Germany.

March 12  Olsson G: Design and operation interactions in wastewater treatment. Task force meeting on real time water quality management, IIASA, Laxenburg, Austria.


March 20  Wittenmark B: Simple self-tuning controllers. Int Symp on Adaptive Control, Bochum, Germany.


April 1  Pernebo L: Algebraisk systemteori (Algebraic system theory) and Vad jag gjorde i USA (What I did in the United States). ASEA Research Lab, Västerås, Sweden.


April 7-16  Åström K J: Stochastic control theory (eight lectures). Institute of Systems Science and Mathematics, Academia Sinica, Peking, China.
April 16  Wittenmark B: System modelling and identification. IIMAS, Mexico City, Mexico.

April 17  Aström K J:
Institute of Systems Science and Mathematics, Academia Sinia, Peking, China.

April 17  Wittenmark B: Comparison of recursive identification methods. IIMAS, Mexico City, Mexico.

April 18  Elmqvist H: Computerized process control. Symposium arranged during a visit by a delegation from Christian Albrechts University in Kiel, Lund Institute of Technology, Sweden.

April 18  Wittenmark B: Adaptive control – an overview. IIMAS, Mexico City, Mexico.

April 20  Aström K J: Identification and control of ship steering dynamics. Shanghai Ship Design and Research Institute, Shanghai, China.

April 21  Aström K J: Research on automatic control in Sweden. Shanghai Jiao Tong University, Shanghai, China.

April 21  Aström K J: Theory and applications of adaptive control. Shanghai Society of Automation, Shanghai, China.

April 21  Wittenmark B: Self-tuning algorithms for control prediction and smoothing. IIMAS, Mexico City, Mexico.

April 23  Wittenmark B: Self-tuning PID-controllers based on pole placement. IIMAS, Mexico City, Mexico.

April 24  Wittenmark B: Applications of self-tuning regulators. IIMAS, Mexico City, Mexico.


May 22

May 29
Molander P: Robusta regulatorer (Robust regulators). Linköping University, Linköping, Sweden.
APPENDIX F - TRAVELS

Karl Johan Aström visited USA in August 1979 to participate in Yale Symposium on Adaptive Control. Participated in 5th IFAC Symposium on Identification and Parameter Estimation in Darmstadt in September. From Sept 1979 to March 1980 Aström was on leave to work at Telsand AB on digital control of a blown film extruder. This project was a FOSAM activity. In January Aström visited the Mathematics Dept at Groningen University, Netherlands, as a member of an international review committee. On Feb 1 to 3 Aström visited IIASA to participate in a meeting with the advisory committee to the system and decision sciences area. March 20-21 he participated in the International Symposium on Adaptive Control in Bochum. In April 1980 Aström was invited to lecture at the Institute of System Sciences in Peking, China. He also visited Shanghai.

Hilding Elmqvist returned in August 1979 from a one year visit to Stanford University. He presented a paper at the Summer Computer Simulation Conference in Toronto, July 1979. During a visit to Italy in Sept 1979 he participated in the 'Sorrento workshop for international standardization of simulation languages' and presented a paper at the IMACS congress. In March 1980 he was invited to Landis & Gyr, Zug, Switzerland, and gave three lectures. He then also visited the Eidgenössische Technische Hochschule and Brown Boveri, Zürich. He also participated in a symposium and a conference on Pascal and Ada in Gothenburg in June 1980.

Per Hagander participated in the conference "Carbohydrate Metabolism: Quantitative Physiology and Mathematical Modeling" in Padova Sept 4-6, 1979, and he then also visited the LADSEB-CNR laboratory. During Sept 10-14 he participated in the 10th International Diabetes Federation Congress in Vienna.

Sven-Erik Mattsson attended the Ada Training Workshop on July 23-27, 1979, at the National Physical Laboratory in London. The course was lead by Jean Ichbiah from CII Honeywell-Bull.

Per Molander visited France on March 18-19, 1980, to attend the conference 'Analyse de systemes', organized by Centre National de Recherche Scientifique, Lyon, France.

Gustaf Olsson has been working full time on a special task on computer planning for the Lund University from July 1, 1979, to March 31, 1980. As part of this commission he visited several European and American university computer centres and departments Sept 2-27, 1979. During this trip he participated in a symposium on 'Computer applications to chemical engineering process design and simulation',
American Chemical Society, Washington DC, Sept 9-14. He also participated in the Univac User's Association meeting in Madrid, Nov 5-10. He made an additional trip to the USA between Dec 4 and 19 and visited computing centres as well as the IEEE conference on decision and control in Fort Lauderdale, Florida. He was invited to join a task force meeting on 'Real time water quality management' at IIASA, Laxenburg, Austria, March 12-14, 1980.

Lars Pernebo visited the USA from Sept 12, 1978, to Sept 28, 1979. After July 1, 1979, he visited the following places: Rice University, Houston, July 30 - Aug 10; Massachusetts Institute of Technology, Boston, Aug 27-31; Yale University, New Haven, Sept 5-7; Brown University, Providence, Sept 10-12; General Electric Research Lab, Schenectady, Sept 14; University of Toronto, Toronto, Sept 17-21.

Jan Sternby participated in the International Symposium on Adaptive Control in Bochum, Germany, on March 20-21 and also presented a paper.

Björn Wittenmark participated in and presented a paper at the IFAC Symposium on Identification and System Parameter Estimation. During December 1-16, 1979, he visited Harvard University, Brown University, and University of Connecticut, where he gave seminars and discussed with colleagues. During the 18th CDC in Ft Lauderdale he organized and lead a session on applications of adaptive control. March 3-7, 1980, he visited LEESA in Rabat, Morocco, and discussed possibilities to set up an exchange program with the Department in Lund. March 20-21 he participated at an International Symposium on Adaptive Control and also presented a paper. During April 14-26 he was invited to lecture at IIMAS at the University of Mexico in Mexico City, Mexico.