Activity Report: Automatic Control 2005

Cervin, Anton; Tuszynski, Agneta

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Automatic Control 2005

Activity Report

Automatic Control 2005

Department of Automatic Control
Lund University
Lund

Mailing address
Department of Automatic Control
Lund Institute of Technology
Box 118
SE–221 00 LUND SWEDEN

Visiting address
Institutionen för Reglerteknik
Lunds Tekniska Högskola
Ole Römers väg 1, Lund

Telephone
Nat 046–222 87 80
Int +46 46 222 87 80

Fax
Nat 046–13 81 18
Int +46 46 13 81 18

Generic email address
control@control.lth.se

WWW and Anonymous FTP
http://www.control.lth.se
ftp://ftp.control.lth.se/pub

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Introduction

This report covers the activities at the Department of Automatic Control, at Lund University from January 1 to December 31, 2005. The budget for 2005 was 27 MSEK. The proportion coming from the university was 52%.

Two PhD theses were defended this year, by Stéphane Velut and Rasmus Olsson. This brings the total number of PhDs graduating from our department to 73. Three Licentiate theses were completed, by Staffan Haugwitz, Pontus Nordfeldt, and Martin Ansbjerg Kjær. Three new PhD student have been admitted during the year: Maria Karlsson, Toivo Perby Henningsson, and Olof Garpinger. During the year four persons with doctor's degree left the department: Stefan Solyom, Johan Bengtsson, Henrik Sandberg, and Rasmus Olsson. Stefan Solyom and Johan Bengtsson started to work for Volvo in Gothenburg, Henrik Sandberg started to work in Pasadena, USA, at California Institute of Technology (Caltech), and Rasmus Olsson for Pidab Instrumentdesign AB, Gothenburg.

In the civilingenjör (master) program we have 13 courses. The total number of students who finished the courses were 916, and 34 students completed their master theses. The total teaching effort corresponds to 130 full-year equivalents.

Research at the department is presented under the following headlines:

Modeling and Control of Complex Systems, Control and Real-Time Computing, Process Control, Robotics, Automotive Systems, and Biomedical Systems.

Today the department has seven professors and one professor emeritus.

Some statistics from five years is given in the table on next page.

	01	02	03	04	05	Sum
Books	0	1	4	0	1	6
Papers	16	21	13	17	15	82
Conference papers	20	44	31	39	27	161
PhD theses	2	1	5	3	2	13
Licentiate theses	1	3	4	2	3	13
Master theses	23	18	19	17	27	101
Internal reports	5	7	2	7	2	23

Acknowledgements

We want to thank our main sponsors: ABB, EU Commission, Swedish Energy Agency (CESOST), Swedish Foundation for Strategic Research (SSF), STEM, The Swedish Agency for Innovation Systems (VINNOVA), The Swedish Research Council (VR), Volvo Powertrain.

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Internet Services

World Wide Web

Visit our home-page at this address:

```
http://www.control.lth.se
```

Our web site contains information about personnel, research, publications, seminars, education, etc. It also contains fairly complete lecture notes for many courses, and in some cases software tools such as Matlab tool-boxes developed at the department. Our home-page first appeared on the World Wide Web (WWW) in April 1994.

Electronic Mail

All personnel can be contacted by electronic mail. A personal email address consists of the full name and the department address, written in the form `FirstName.LastName@control.lth.se`. Double names are separated by underline, hyphens are treated as ordinary characters, and accents are ignored. Examples:

```
anders.rantzer@control.lth.se
karl-erik.arzen@control.lth.se
```

Our web page `http://www.control.lth.se/people/telemail.html` contains a complete list of email addresses and phone numbers. The department also has a generic email address:

```
control@control.lth.se
```

Emails to this address are continuously read by the postmaster and forwarded to the appropriate receiver.

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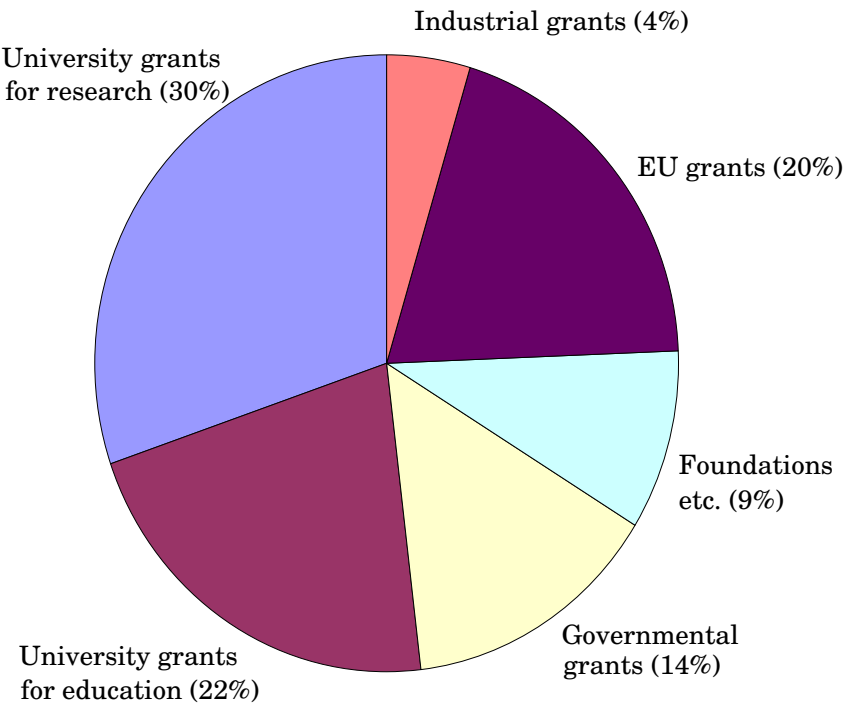
Economy and Facilities

The turnover for 2005 was 27 MSEK. The income comes from Lund University (52%) and from external grants; the distribution is shown below.



Funding

Lund University provides partial support for graduate students. The majority of our research is, however, externally funded from governmental agencies and industry. During 2005 we had the following contracts:

- VR – Control of Complex and Nonlinear Systems (block grant)
- VR – Decentralized Structures for Industrial Control
- VR – Control and Verification of Systems with State Constraints
- VINNOVA – Diesel-HCCI in Multi Cylinder Motor, together with Volvo Powertrain Corporation
- VINNOVA – Lund Center for Applied Software Research (LUCAS)
- VINNOVA – Green Car HCCI
- SSF – Center for Chemical Process Design and Control (CPDC)
- SSF – Flexible Embedded Control Systems (FLEXCON)
- SSF – Flexible and Accurate Automation
- SSF – Decentralized control of complex systems, Senior Individual Grant, SIG Anders Rantzer
- EU IST 2001-33520 – Control and Computation (CC)
- EU IST-004536 – Reconfigurable Ubiquitous Networked Embedded Systems (RUNES)
- EU IST-004175 – Complex Embedded Automotive Control Systems (CEmACS)
- EU IST-004527 – ARTIST2: Embedded Systems Design (ARTIST2)
- EU IST-511368 HYbridCONtrol – Taming Heterogeneity and Complexity of Networked Embedded Systems (HYCON)
- EU IST-507728 EURON II NoE, Member agreement
- EU NMP2-CT-2005-011838 – The European Robot Initiative for Strengthening the Competitiveness of SMES in Manufacturing (SMErobot)
- ABB Automation Technology Products/Business Unit Robotics (Research Collaboration)
- ABB – PhD Research Project
- Alfa Laval Lund AB – Research and Development Agreement
- Mid Sweden University – PhD Research Project
- Haldex Brake Products AB – PhD Research Project
- Toyota Motor Corporation – Simulation Model

- Swedish Energy Agency (STEM) – Active Control of Combustion Oscillations in Gas Turbines (CECOST)
- Royal Physiographic Society – Scholarship
- Jacob Letterstedt - Scholarship
- Knut and Alice Wallenberg – Scholarship
- Foundation of Per Westlings – Scholarship
- Foundation Sigfrid and Walborg Nordkvist – Scholarship
- Foundation Aeryleanska Traveling Scholarship – Scholarship

The block grant from VR and the CPDC grant from SSF are long range and also some of the VINNOVA projects are long range. Several projects do, however, have a duration of only two years. To match these with the duration of a PhD, which is much longer, we have an internal research planning that is much more long range and we are careful to bid on projects that fit our long range research plan. This has proven an effective way to match short-term funding to long-term planning.

Facilities

Teaching Laboratory

The teaching laboratories are based on desktop processes and personal computers. These laboratories are used in all our courses. The introductory courses give a heavy load on the teaching laboratories because of the large number of students. There are about 1000 students, and on the average they spend about 20 hours each in the lab.

New Lab Equipment and Processes

Within the EU-project SMErobot a new type of parallel kinematic manipulators (PKMs) have been built, based on the ideas and patents of Dr. Torgny Brogårdh, ABB Robotics. The Gantry-Tau robot is a PKM with linear actuation of (at least) 3 degrees of freedom. In addition to a full scale version in the Robotics Lab, also a small scale model of the Gantry-Tau parallel kinematic robot has been built at the Department by Rolf Braun, see Figure 3.1. The three linear actuators are controlled via an ATMEL-interface, which also takes care of the sensor interface, with measurements from analog linear encoders on the arm-side. The robot can be run directly from Matlab with the real-time extension developed at the

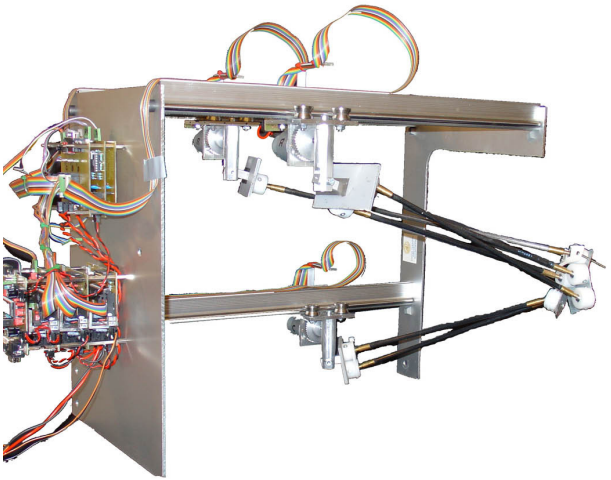


Figure 3.1 Small scale model of a Gantry-Tau parallel kinematic robot. The three linear actuators are controlled via an ATMEL-interface.

department [1]. For the table model a full set of link arms with magnetic spherical joints have been constructed, see Figure 3.2. This makes it easy to reconfigure the robot and to evaluate different arm configurations and kinematic properties, such as e.g., work space due to joint limitations etc.

Control over Wireless Sensor Networks

The RBbot, see Figure 3.3, was built as an experimental platform for wireless networked control using sensor networks. The RBbot consists of an inverted pendulum on top of a three-wheeled cart and is equipped with a Telos Rev B wireless sensor node for local control and communication. The cart also contains one ATMEL Mega16 and two ATMEL Mega8 processors for low-level motor control, pendulum angle readings, and I2C communication with the Telos node.

The RBbot was used in the course Projects in Automatic Control, in which both local and remote control was investigated. In the latter case, the control loops were closed over a distributed sensor network.

[1] `http://www.control.lth.se/user/anders.blomdell/linux_in_control/`

Figure 3.2 Magnetic spherical joints for easy reconfiguration of arm links for the table model of the Gantry-Tau parallel kinematic robot.

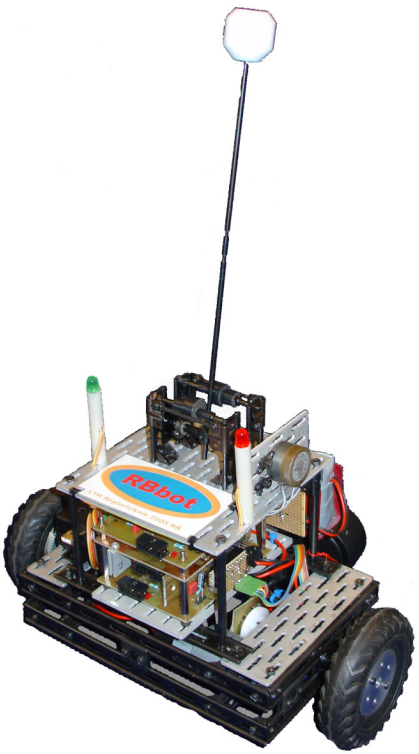


Figure 3.3 RBbot

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Education

Engineering Program

The engineering education follows the central European systems with a 4.5 year program leading up to the degree “civilingenjör” (civ.ing.), which corresponds to an MSc in the US and British systems.

Automatic control courses are taught as part of the engineering curricula in Engineering Physics (F), Electrical Engineering (E), Computer Engineering (D), Mechanical Engineering (M), Industrial Management and Engineering (I), Chemical Engineering (K), Environmental Engineering (W), Information & Communication Engineering (C), Engineering Mathematics (Pi), and Engineering Nanoscience (N). Our courses are listed in Table 4.1. During 2005, 916 students passed our courses and 34 students completed their master’s thesis projects. The number of registered students corresponded to 130 full-year equivalents during the year. The numbers for 2004 were 950, 24, and 147 respectively.

Information on WWW

Many students have access to Internet via Lund University. Therefore we have made a great effort to present the education on web pages. Each course in the engineering program has its own home-page, where the students can find course plans, lecture notes, documentation, manuals, old exams, etc.

We have also information sheets about the engineering courses and the doctorate program. You find the education links at `http://www.control.lth.se/education/`.

Table 4.1 Courses and the number of students who passed.

Reglerteknik AK(FEDIMPi) *FRT010* (Automatic Control, basic course)	426
Reglerteknik (C) *FRT065* (Control)	33
Processreglering (K) *FRT081* (Automatic Process Control)	23
Systemteknik (WN) *FRT110* (Systems Engineering)	89
Digital Reglering *FRT020* (Computer-Controlled Systems)	88
Realtidssystem *FRT031* (Real-Time Systems)	67
Systemidentifiering *FRT041* (System Identification)	15
Adaptiv reglering *FRT050* (Adaptive Control)	34
Olinjär reglering och Servosystem *FRT075* (Nonlinear Control and Servo Systems)	32
Internationell projektkurs i reglerteknik *FRT100* (International Project Course in Automatic Control)	11
Projekt i reglerteknik *FRT090* (Project in Automatic Control)	13
Reglerteori *FRT130* (Control Theory)	36
Matematisk modellering, FK *FRT095* (Mathematical Modelling, Advanced Course)	49
Examensarbete 20 poäng *FRT820* (Master-thesis project, 5 months)	34

Doctorate Program

Two PhD theses were defended, by Stéphane Velut and Rasmus Olsson. This brings the total number of PhDs graduating from our department to 73. Three licentiate theses were completed, by Staffan Haugwitz, Pontus Nordfeldt, and Martin Kjær. Abstracts of the theses are given in Chapter 7.

We have admitted three new PhD students during the year, Maria Karlsson, Toivo Perby Henningsson, and Olof Garpinger.

The following PhD courses were given:

- Introduction to the Modelica Language (Hubertus Tummescheit, Jonas Eborn, Magnus Gäfvert, Modelon) 5 points

- Convex Optimization with Applications (Anders Rantzer) 5 points
- Control of Oscillations in Nonlinear Systems (Anton Shiriaev, Umeå University) 2 points
- Linear Systems (Per Hagander) 6 points
- Model Predictive Control (Staffan Haugwitz and Ola Slätteke) 3 points.

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Research

The goal of the department is to provide students with a solid theoretical foundation combined with a good engineering ability. This is reflected in the research program which covers both theory and applications.

The major research areas are:

- Modeling and Control of Complex Systems
- Control and Real-Time Computing
- Process Control
- Robotics
- Automotive Systems
- Biomedical Systems

In the following presentation the research is in most cases broken down to the granularity of a PhD thesis. There are of course strong relations between the different projects.

Modeling and Control of Complex Systems

Distributed Estimation and Control

Researchers: Peter Alriksson, Ather Gattami, and Anders Rantzer

How should control equipment distributed across the power grid in southern Scandinavia cooperate to quickly find new transmission routes when a power line is broken? How should the electronic stabilization programme (ESP) of a car gather measurements from wheels and suspensions and decide how to use available brakes and engine power to recover from a dangerous situation? How can a large number of sensors and actuators be coordinated to control the dynamics of a flexible mechanical structure?

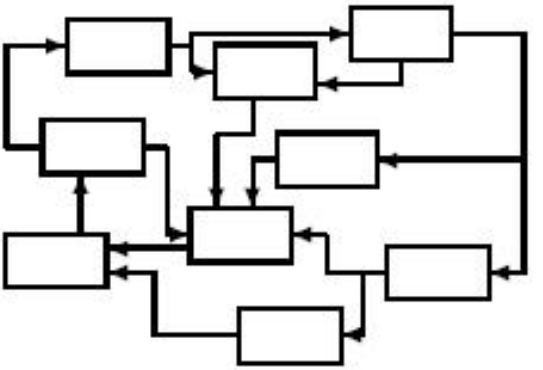

Figure 5.1 A distributed control system.

All these questions are examples of distributed control problems, where several controllers need to cooperate with access to different information and with bounds on the communication between them. Most of traditional control theory was developed with a centralized viewpoint. However, recently important steps were taken in the new direction of distributed control theory, building on a historical development dating back to economic game theory and statistical decision theory from the 1960s.

We are currently addressing these problems from a general system theoretic viewpoint, but with particular attention to the following three applications:

- Control of power networks
- Dynamic positioning of laboratory vehicles using sensor networks
- Control of a flexible mirror for an astronomic telescope

Relaxed Dynamic Programming

Researchers: Peter Alriksson, Anders Rantzer, and Andreas Wernrud

A new approach to synthesis of nonlinear and hybrid observers and controllers is currently developed by extending the classical idea of dynamic programming. This method was introduced by Bellman in the 1950's and has found many important applications since then. The idea is general and very simple, but the "curse of dimensionality" is often

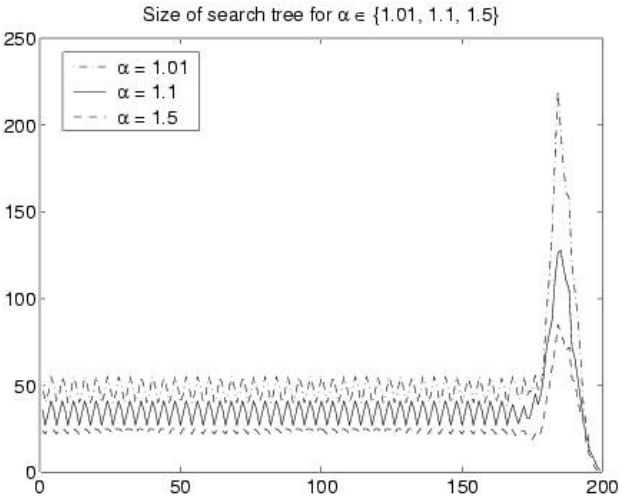

Figure 5.2 The figure illustrates an example where the cost to go is computed backwards in time, starting at T=200. The three parameter values 1.01, 1.1 and 1.5 correspond to accuracies of 1%, 10% and 50% respectively. Notice that the size of the search tree first grows exponentially for time steps down to about T=180, then the size starts to shrink and finally stabilizes at a lower level that depends on the requested optimization accuracy.

prohibitive and has previously restricted most applications to a discrete state space of moderate size. Our idea is to use a relaxed version of dynamic programming to find approximations of the cost function. It turns out that finding a solution which is guaranteed to be within 10% from the optimum can be much less expensive than finding one within 1%.

Our current research on this topic includes performance analysis in model-predictive control, optimal estimation using sensor switching and control synthesis for DC-DC converters.

Modeling and Validation of Nonlinear Systems

Researchers: Oskar Nilsson, Anders Rantzer, Andreas Wernrud, and Karl Johan Åström

Large complex mathematical models are regularly used for simulation and prediction. However, in control design it is common practice to work with as simple process models as possible. This makes it easier to analyze and evaluate the model, or to use it inside the controller for on-line estimation

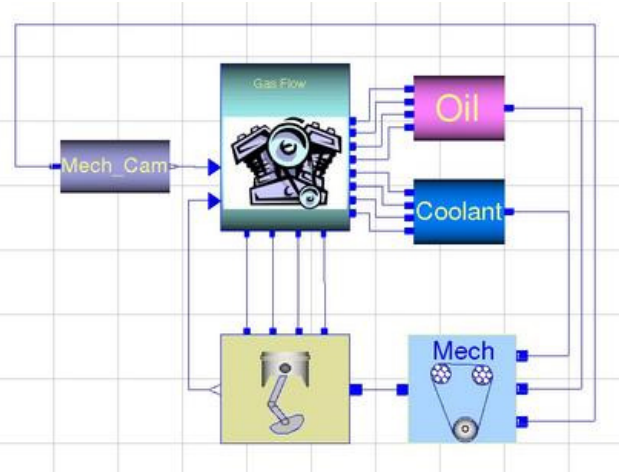

Figure 5.3 Schematic picture of an engine model

of important variables. One objective of this project is to develop methods and tools that can take a complex model and deduce simple models for various purposes and also to derive bounds on the approximation error.

Current work is based on the method of balanced truncation and its extension to nonlinear systems. Analysis is done based on linearization around simulated trajectories. Engine models from Toyota Motor Corporation are used as test cases.

Language Support for Dynamic Optimization

Researchers: Johan Åkesson and Karl-Erik Årzén

Overview The primary area of research in this project is languages for dynamic, model based optimization. The research problem is to investigate the possibility to create a language offering a higher level of abstraction for formulating dynamic optimization problems for a certain class of dynamic models. The research opportunity stems from the observation that there seems to be no strong initiative in this direction applicable to dynamic optimization, as is the case in the field of dynamic modeling and simulation.

An integral part of formulating a dynamic optimization problem is the description of the system dynamics. Modelica, being a language for modelling of dynamical systems, will be considered for this purpose. The language for dynamic optimization to be developed can be viewed as an extension or a complement to Modelica, where Modelica is used to expressing the system dynamics and the new optimization language is used to express optimization quantities as cost function, constraints, control variable discretization etc.

The primary aim of the research is to create a language for dynamic optimization problems which builds on Modelicas capabilities to express dynamical models. A secondary aim is to create a prototype implementation which implements a subset of the language and enables solution of a certain class of optimization problems by means of a sequential method and to perform one or more case studies.

Isn't Modelica Enough? Although being a very rich language in terms of expressive power for describing complex (hybrid) dynamical systems, Modelica lacks important features desirable for expressing optimization problems. This is quite natural since the scope of Modelica does not include optimization. However, Modelica may well be used to describe an important component of the dynamic optimization problem, namely the dynamics. Further, much effort has been put into developing libraries for many application fields using Modelica which enables rapid development of component based models.

The new language for dynamic optimization should be thought of as a complement to Modelica, which is used to express optimization specific quantities other than the dynamics.

Application Example: Grade Changes Typically, chemical processes are designed and optimized for steady state operation. Also, processes are often controlled by local controllers. This setup leaves, in many cases, to the operators to manage situations as start ups, state transitions (grade changes) and shut downs. Efficient handling of production transitions is critical in a competitive business environment, where the demand is turning to diversification and tailored products. Operator support for grade changes is therefore of interest. This projects addresses the grade change problem by combining optimization techniques and sequential control.

By using an optimization formulation, many critical issues of process state transitions may be expressed. For example, by formulating a minimum time optimization problem, the performance of a grade change may be improved. Also, by imposing constraints on critical process and control variables, safety issues can be dealt with. The aim of the optimization procedure is to generate sequences of reference commands for the process. Normally, the process is equipped with a Digital Control System (DCS), that implements local control loops. In this case the interaction between the process and the DCS will have to be taken into consideration.

For sequential control, the graphical sequence control language Grafchart, and in particular, the Java based Grafchart implementation JGrafchart will be used. Grafchart offers primitives for designing event driven control schemes, and fits nicely into the framework of grade changes. For example, generation of reference command sequences expressed as Grafcharts would be of interest.

Hybrid Control – HYCON Network of Exellence

Researchers: Peter Alriksson, Per Hagander, Staffan Haugwitz, Toivo Henningsson Perby, Rolf Johansson, Oskar Nilsson, Anders Rantzer, Anders Robertsson, and Andreas Wernrud in collaboration with the other partners of the HYCON NoE.

HYCON is an EU/IST FP6 Network of Excellence on hybrid control systems. The objective of the NoE HYCON is establishing a durable community of leading researchers and practitioners who develop and apply hybrid systems theory to the design of networked embedded control systems as found in industrial production, transportation systems, generation and distribution of energy, communication systems.

HYCON has four research work-packages. Lund is active in all of them:

- Energy management
- Industrial control
- Automotive control
- Networked control

In June 1-2, 2006 all HYCON work packages gather for the first time in one meeting. This will be in Lund and our department serves as host.

Inducing Stable Oscillations in Nonlinear Systems by Feedback

Researchers: Anders Robertsson and Rolf Johansson in cooperation with Prof. Anton Shiriaev and Dr. Leonid Freidovich, Umeå University

The aim of this project is to develop feedback control laws for nonlinear dynamical systems represented by the classical Euler-Lagrange equations. We consider the systems with the number of actuators being less than the number of its degrees of freedom (DOF) by one. Examples of such dynamical systems are ubiquitous, for instance, a cart-pendulum system (2 DOF correspond to position of the cart and angle of the pendulum, 1 actuator produces the force applied to the cart) and a model of a ship on a plane (3 DOF; 2 actuators). The two problems, approached in the project, are: how to derive a simple and efficient algorithm of motion planning for such a under-actuated systems and how to make a pre-planned motion orbitally stable in the closed loop.

It is well known that feedback control design for under-actuated systems is inherently difficult task since not every desired motion is feasible for a system with not actuated DOF. Our controller design approach is based on the idea of virtual holonomic constraint: geometrical relations imposed between generalized coordinates, which are made invariant for the closed loop system. Exploiting this idea, we have obtained series of preliminary results, in particular, on reducibility of dynamics, integrability of zero dynamics, extension of the famous Lyapunov lemma on presence of center in a nonlinear system, constructive procedure for exponential orbital stabilization of pre-planned motions, extensions to hybrid dynamical systems.

This project is supported by the Swedish Research Council, Ref. 2005-4182.

Control and Real-Time Computing

Flexible Embedded Control Systems (FLEXCON)

Researchers: Dan Henriksson, Anders Blomdell, Anton Cervin, and Karl-Erik Årzén, in collaboration with the Department of Computer Science at Lund University, DAMEK at KTH, MRTC at Mälardalen University, and DRTS at University of Skövde

Control and automation systems constitute an important subclass of embedded real-time systems. Control systems have traditionally been relatively static systems. However, technology advances and market demands are rapidly changing the situation. The increased connectivity implied by Internet and mobile device technology will have a major impact on control system architectures. Products are often based on commercial-off-the-shelf (COTS) components. The rapid development of component-based technologies and languages like Java and C# increases portability and safety, and makes heterogeneous distributed control-system platforms possible. The evolution from static systems towards dynamic systems makes flexibility a key design attribute for future systems.

The key challenge of FLEXCON is how to provide flexibility and reliability in embedded control systems implemented with COTS component-based computing and communications technology. Research will be performed on design and implementation techniques that support dynamic run-time flexibility with respect to, e.g., changes in workload and resource utilization patterns. The use of control-theoretical approaches for modeling, analysis, and design of embedded systems is a promising approach to control uncertainty and to provide flexibility, which will be investigated within FLEXCON. Other focal points are quality-of-service (QoS) issues in control systems, and testing-based verification and monitoring of flexible embedded control systems. The main application area is adaptive industrial automation systems. An industrial robotics-based demonstrator will serve as the carrier of the project results.

Reconfigurable Ubiquitous Networked Embedded Systems (RUNES)

Researchers: Martin Andersson, Dan Henriksson, Anton Cervin, Peter Alriksson, and Karl-Erik Årzén in collaboration with the other partners in the RUNES project.

RUNES is an EU/IST FP6 integrated project on networked embedded systems with special focus on sensor/actuator networks, that started

September 1, 2004. RUNES is coordinated by Ericsson and consists of 23 industrial or academic partners.

Our participation in RUNES is focused on three areas:

- control over sensor networks
- control of network resources
- simulation tools for sensor/actuator network

Within the project we are extending the TrueTime toolbox with support for simulation of wireless battery-powered nodes. We are also extending the control server model to networked control loops.

Partly within RUNES and partly in a student project course we have developed a sensor-network based mobile inverted pendulum robot. See Figure 3.3. The objectives of the project were to develop a test case for control over sensor networks and investigate the performance that can be achieved using state of the art sensor network technology such as TelosB motes with ZigBee radio communication. An inverted pendulum is mounted on the robot. The task is to stabilize the pendulum while driving around in an environment where sensor network nodes are located. The robot contains two ATMEL AVR Mega8 processors (for the wheel motor control), one ATMEL AVR Mega16 processor (for the pendulum angle sensor interface) and one TelosB mote. The control of the pendulums is either done locally on the robot mote or remotely on some other mote.

Design of Embedded Systems (ARTIST2)
Researchers: Martin Andersson, Dan Henriksson, Anders Robertsson, Anton Cervin, and Karl-Erik Årzén in collaboration with the other partners of the ARTIST2 NoE.

ARTIST2 is an EU/IST FP6 network of excellence on design of embedded systems. The objective of ARTIST2 is to strengthen European research in Embedded Systems Design, and promote the emergence of this new multi-disciplinary area. ARTIST2 gathers together the best European teams from the composing disciplines, and will work to forge a scientific community.

Internally ARTIST2 is divided into seven clusters (Modelling and Components, Hard Real-Time, Adaptive Real-Time, Compilers and Timing Analysis, Execution Platforms, Control for Embedded Systems, Testing and Verification). Lund is a member of the cluster Control for Embedded Systems with Karl-Erik Årzén as the cluster leader. The other nodes is this cluster are KTH, Czech Technical University, and the Polytechnical University of Valencia. The work within the cluster is focused on three areas:

- Control of Real-Time Computing Systems
- Real-Time Techniques in Control System Implementation
- Co-Design Tools for Control, Computing, and Communication

LUCAS Center for Applied Software Research

Researchers: Karl-Erik Årzén, Rolf Johansson, Anders Robertsson, Anton Cervin, Dan Henriksson, Martin Andersson, Rasmus Olsson, Anders Blomdell, and Leif Andersson in collaboration with Department of Computer Science, Department of Communication Systems, and industry.

The Center for Applied Software Research (LUCAS) is a collaboration between the software-oriented parts of three departments at LTH:

- Computer Science
- Communication Systems
- Automatic Control

In total around 15 faculty members and 20 PhD students are involved in LUCAS. The focus of LUCAS is industrially-oriented and motivated software research. This includes research on software engineering, software technology, and software applications. Special focus is put on real-time systems, in particular embedded systems, networked systems, and control systems. The work is organized along three thematic areas:

- Software Engineering Environments
- Methods in Software Engineering
- Real-Time Systems Software

The first thematic area focuses on the core areas of integrated environments (tools and methods), object-oriented languages in the tradition of Simula, Beta, and Java, and embedded systems. The research method is focused on experimental implementation and development of relevant theory. Examples of issues that are studied are configuration management, collaboration support, domain-specific languages, frameworks and patterns and Java for embedded systems. The second thematic area is focused on software development processes, methods and architectural issues for development and maintenance of complex software systems. More specifically, the research is directed towards the following key areas: software quality, verification and validation, requirements engineering, and software process architectures. The research is approached through empirical studies to understand, assess, and improve software development.

The third thematic area is focused on the software aspects of real-time systems, in particular embedded system, networked systems, and control systems. Some examples of topics within the area are real-time kernels and run-time systems for embedded systems, system architectures for real-time control systems in e.g., industrial automation and robotics, integrated approaches to control design and CPU and communication bandwidth scheduling, and verification and validation of real-time systems.

The activities within LUCAS consist of research projects in collaboration with industry, center activities, and teaching activities. The projects can span the full range of LUCAS or be focused on one of the thematic areas. The aim of the center activities is to maintain the infrastructure of LUCAS and to disseminate information among the partners. The teaching activities include both graduate-level courses and continued education courses.

Industries can join LUCAS at three levels of participation. A gold member is involved in projects over the full range of LUCAS and has a long-term strategic interest in the activities of LUCAS. Silver participants are involved in a single research project, whereas bronze members have access to the LUCAS network in terms of seminars, tutorials, courses, and workshops.

Control of Computer Server Systems

Researchers: Anders Robertsson and Björn Wittenmark, in cooperation with Maria Kihl and Mikael Andersson, Department of Telecommunications, Lund University. Dan Henriksson in cooperation with Tarek Abdelzaher, Department of Computer Science, University of Virginia

We are working on control of network server systems along two parallel lines.

Admission Control In a collaboration with the Dept of Telecommunication at Lund University we study admission control schemes. In this project we consider modeling of network service control nodes and the use of nonlinear control theory for analysis and design of admission control schemes.

In the last couple of years “Communication and Control” has gained large attention and a lot of new research has focused on control of and over networks. However, the admission control problem, which is important for the utilization and the robustness of the network still remains as an rather unexplored area. Here, we believe the interaction of queuing theory and nonlinear control play a major role.

During the project a discrete-time model of server nodes has been found which aligns well with the properties of the discrete-event models from the queuing theory. The different control algorithms and the effect of different arrival and service process distributions are evaluated experimentally on an Apache web server in a laboratory network. A traffic generator is used to represent client requests. The control of the Apache server has been re-written to implement our algorithms. We show that the control theoretic model aligns well with the experiments on the web-server. Stability analysis and controller design for both continuous and discrete-time models are considered.

Service Rate Control In a collaboration with Tarek Abdelzaher at Univ of Virginia (currently at Univ of Illinois) we study service rate control of web-servers. An control scheme based on feedforward using an instantaneous queue model together with event-based PI feedback has been developed. The advantage of the instantaneous queue model is that no assumptions are made about the stochastic nature of the traffic.

Process Control

PID Control

Researchers: Karl Johan Åström and Tore Hägglund

This project has been in progress since the beginning of the eighties, and resulted in industrial products as well as several PhD theses. Three monographs on PID control that are based on experiences obtained in the project have also been published.

The first book, "Automatic Tuning of PID Controllers", 1988, which had 6 chapters, gave a short description of our early experiences with development of relay auto-tuners. The second book, "PID Controllers: Theory, Design, and Tuning", 1995, which has 7 chapters, grew out of the need for a broader coverage of many aspects of PID control. In particular, it reviews many design methods for PID controllers that we investigated in connection with our work on auto-tuners. In 2005, the last book "Advanced PID Control" was published. With a total of 13 chapters, this new book substantially expands on some of the topics covered in the previous versions and provides several new chapters that deal with controller design, feedforward design, replacement of the Ziegler-Nichols tuning rules, predictive control, loop and performance assessment, and interaction.

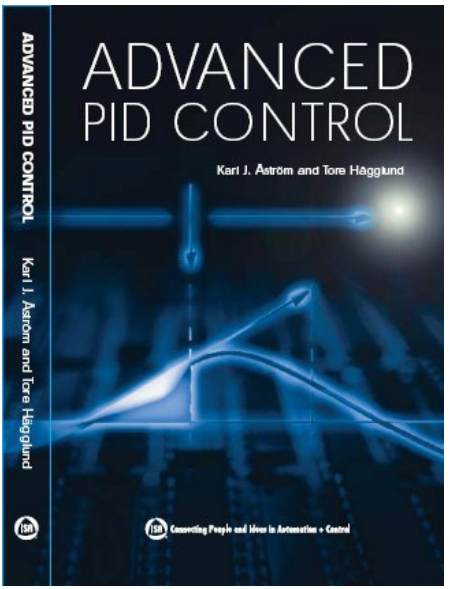

Figure 5.4 The book "Advanced PID Control".

In the PhD theses *PID Control – Design, Extension, Application* by Hélène Panagopoulos, efficient design methods for PID controllers were presented. These methods are based on constrained optimization and require that a process transfer function is available.

During the last years, these design methods have been used to develop simple tuning rules that are based on simple process models obtained step or frequency response experiments. The design rules are named AMIGO (Approximate M-constrained integral gain optimization). A sequence of five papers have been written that treat PI and PID control based on step and frequency response methods, and a combination of step and frequency responses.

We have also started to develop interactive learning modules for PID control. The modules are designed to speed up learning and to enhance understanding of the behaviour of loops with PID controllers. The modules are implemented in SysQuake, and the work is done in collaboration with professor Sebastián Dormido at UNED, Madrid, and José Luis Guzmán at Universidad de Almería.

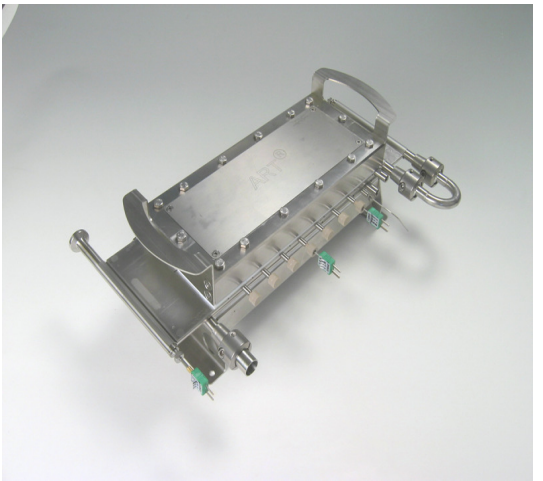

Figure 5.5 A plate reactor for use in small laboratories. Courtesy of Alfa Laval AB.

Control of the Open Plate Reactor

Researchers: Staffan Haugwitz and Per Hagander

The project, which started in September 2002, is aiming at improving process control of chemical reactors, especially the novel Open Plate Reactor, now being developed by Alfa Laval AB. The project is partially funded by HYCON, work package 4b, "Large transitions in processing plants". The Open Plate Reactor (OPR) is a combination of a plate heat exchanger and a chemical reactor, see Figure 5.5. One side is used chemical reactions and on each side there are cooling/heating plates. Depending on the reaction, there is a need for the water flow to cool or heat the reactor, i.e. if the reaction is exothermic or endothermic.

When the reactions are exothermic and fast, the reactants are often dissolved into low concentration solutions to ensure that the temperature in the tank reactor does not rise above a dangerous level. By using a plate reactor, solutions of higher concentrations can be used, thus increasing the productivity and safety. The plate reactor can be approximated as a one dimensional tube reactor. A typical reaction can be stated as:

$$A + B \rightarrow C + D$$

Reactant A enters the plate reactor at the upper left corner, see Figure 5.6. Reactant B is injected in multiple places along the tube reactor, in order

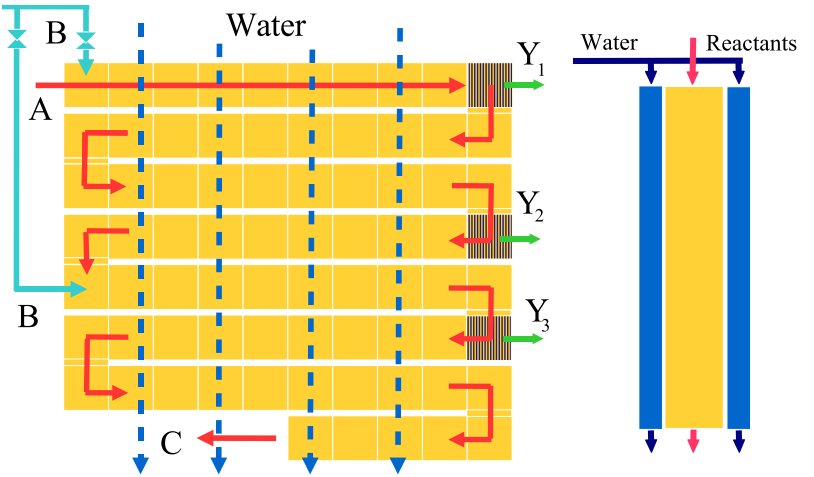

Figure 5.6 Left: A schematic figure of a few rows of a reactor plate. Reactant *A* is injected at top left and reactant *B* is injected at multiple sites along the reactor. Y_1, Y_2 and Y_3 are internal temperature sensors used for process control and supervision. Right: The plate reactor seen from the side with cooling plates on each side of the reactor part.

to use the entire length of the reactor. When reactant A and B mix, the substances C and D are produced. If the reaction is exothermic, heat is generated and the temperature of the fluid increases. For each injection point, there will be a local temperature maximum. To cool the reactor cold water flows on each side of the reactor. The reactor construction is very flexible, where the number of plates, injection sites and sensor locations can be varied to fit various chemical reactions.

The plate reactor is very interesting from a control point of view. It has internal sensors enabling accurate information about temperature and also indirect concentrations inside the reactor. With multiple injection points the heat generated from the exothermic reactions can be re-distributed for an improved safety and performance.

The primary control objective is to guarantee safety in terms of the temperature inside the reactor. In addition the plate reactor should be controlled so that the reaction yield, that is the chemical efficiency is maximized. The control system should be robust towards disturbances and variations in inlet feed conditions. One crucial part of the control system will be the start-up procedure. The objectives of the control system can be summarized as:

- Utilize reactor maximally in a safe way

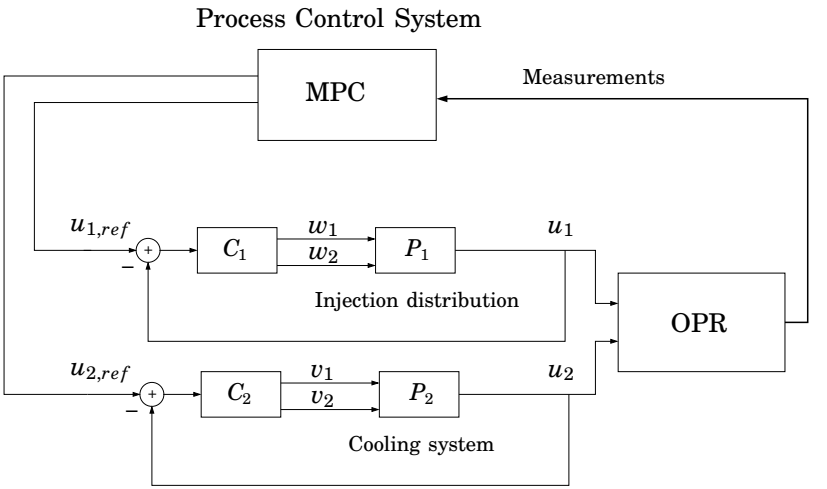

Figure 5.7 Control structure for the OPR. The Process control system uses Model Predictive Control (MPC) to calculate the optimal control signals u_1 and u_2. These signals are then sent to the injection distribution C_1 and cooling temperature C_2 controllers.

- Reaction is to be completed within the reactor
- Reactants are to be in the right proportions
- Should be able to work with highly concentrated solutions
- Avoid side reactions
- Achieve and maintain desired operating conditions
- Fast and safe start-up/shut-down
- Emergency shut-down procedure
- Robustness towards disturbances in the process

The start-up procedure of the OPR can be challenging, especially when there are strongly exothermic reactions. This has been studied within the HYCON project “Large transitions in processing plants”. A process control system for the reactor has been designed and tested in simulations. Model Predictive Control (MPC) is used to calculate suitable injection flows and cooling temperatures, see Figure 5.7. Reactant injection and cooling temperature controllers are designed separately to be placed in a cascade with the MPC.

A utility system has been designed, which delivers cooling water with desired temperature and flow rate. A temperature controller using a mid-ranging control structure has been developed. The utility system, seen in Figure. 5.8, has been assembled at Alfa Laval facilities in Lund. Experiments to investigate the control properties of the plate reactor and to test the temperature control system have been conducted successfully.

The designed process control system increases the safety of operations by reducing the impact from external disturbances. This will also decrease the risk of unnecessary shutdowns of the process operation. An article

Figure 5.8 The experimental test unit, with the plate reactor to the left.

"Process control of an Open Plate Reactor", about the OPR and the control system, was presented at the IFAC World Congress in Prague and it achieved the best control application paper award. An extended version of the paper will be published in Control Engineering Practice during 2006.

An article "Anti-windup in Mid-ranging control" was presented at the CDC-ECC conference in Seville. Experiments were carried out with the test unit, see Figure 5.8, to confirm the theoretical results.

New Control Strategies in the Dryer Section of the Paper Machine

Researchers: Jenny Ekvall, Tore Hägglund

This is a joint project between the Network for Process Intelligence (NPI) at the Mid Sweden University and Lund University.

In a first phase, a model of a drying cylinder, describing the relation between the steam pressure and the cylinder temperature, has been developed and implemented in Matlab-Simulink. The model has been validated through experiments performed at the M-real Husum mill.

After validation, the model has been used to derive optimal control strategies of the steam pressure during web breaks. The goal of the strategy is to control the steam pressure so that the production is restarted with the same drying properties of the cylinder as before the break. The new control strategy has been tested and is currently in use at the M-real Husum mill. This phase of the project has resulted in a licentiate thesis by Jenny Ekvall.

In the second phase of the project, a Modelica model of the whole drying section is developed. This model will be used to investigate new control strategies for control of the moisture content in the paper web. See Figure 5.9.

Modeling and Control of the Drying Sections of a Paper Machine

Researchers: Ole Slätteke, Tore Hägglund, and Björn Wittenmark

The paper making process is essentially a very large drainage process. Consistency of the stock flow entering the paper machine head box is typically around 0.2drying section is responsible for removing less than 1water content, this is the part of the paper machine that, by far, consumes most energy. It is also in the drying section where most paper web strength forms and web shrinkage occurs and the part where the actual moisture control is performed. These are some of the reasons why this part of the paper machine is critical for the final paper qualities.

A dryer section in a paper machine can consist of up to one hundred steam heated cylinder and the length of the drying section can be above 100 meters. See Figure 5.10. The cylinders are divided in 5 - 10 steam groups. The control of the steam pressure in these cylinder groups is in cascade control with the moisture control loop. This project is focused on the modeling and control tuning of this process. From mathematical model building and experiments on industrial paper machines it is found that the dynamics from the steam valve to the steam pressure in the cylinders

Figure 5.9 Steam cylinder temperature measuring.

Figure 5.10 Schematic illustration of a paper machine. The direction of the paper production is from left to right. The dryer section, with its steam heated cylinders, is the pink area in the figure.

can be described by a simple process model, the so called IPZ model. This model has an integrator, one pole, and one zero. The dynamics from the steam pressure set point to the moisture in the paper can be described by a first order model plus dead time, where the dead time is a dominating part.

Many tuning methods for PI and PID control have been proposed previously but most of them exclusively suppose a first-order system with dead time or an integrating process with dead time. Since this does not fit very well to the IPZ-process, a new method is necessary. Therefore a simple tuning method for both PI and PID control of the steam pressure in the

cylinders has been developed that is based on the four process parameters of the IPZ model. These process parameters can easily be obtained by a simple open loop step response. The design goal is to obtain good load disturbance response and to give the user the option to balance between robustness and performance; the tuning rule has a design parameter. The tuning rule has been tested and evaluated on different paper machines in Sweden.

From mass and energy balances, a simulation package with components of a drying section has been implemented in the object-oriented modeling language Modelica. By drag-and-drop features, a model of practically any drying section can easily be built. The model is non-linear and has been validated against plant data. It can be used to investigate effects of a rebuild, different controller structures, and different ways to operate the machine. All this can be done for web breaks, grade changes, start-ups, and normal run. Another purpose of the model is optimization of e.g. steam usage or paper quality. The model has been used to verify a new moisture control structure, implemented in a model predictive controller (MPC).

In collaboration with The Department of Chemical Engineering in Lund, a new principle of control in the drying section has been examined by simulations. Instead of only using the steam heated cylinders to control the moisture, the air system is also incorporated into the control structure by mid-ranging. Specifically, the dew point and velocity of the air blown onto the paper web is used to control the moisture in the paper while the steam pressure is set at a level where the air system has an adequate control range in both directions. Simulations have given promising results by showing that the bandwidth of the mid-ranging controller is more than twice as large as the conventional controller. A feedforward structure to further improve the performance of the moisture control loop has also been implemented. A new signal is proposed for the feedforward that is based on the surface temperature of the paper web. Simulation results show that the disturbance rejection is greatly improved.

Active Control of Combustion Oscillations in Gas Turbines

Researchers: Rolf Johansson, Martin A. Kjær in cooperation with CECOST (Dr. Jens Klingmann, Prof. Tord Torisson, Adj. Prof. Rolf Gabrielsson) and Siemens

Today's strict environmental regulations are resulting in increasingly higher demands for more efficient gas turbines that provide ever lower emissions levels. This has lead to a continuous development of methods and concepts for competitive and robust combustors. In lean premixed

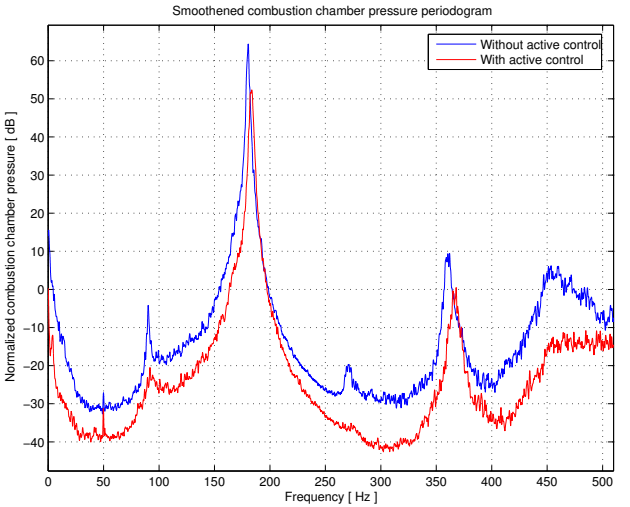

Figure 5.11 Power spectrum of combustion chamber pressure. The blue line indicates the unactuated pressure, the red line indicating the pressure during active control.

(LP) combustion the incoming fuel is mixed prior to combustion with the air stream delivered by the compressor. When the fuel is diluted by the air, the heat release is distributed in a bigger volume which results in lower local flame temperatures and thus less formation of NOx. The lower temperatures in the primary combustion zone make it more difficult to sustain stable combustion during transients and part load operation. It is therefore desirable to control the combustion process during operation actively with respect to certain characteristic stability parameters.

A lean premixed combustion rig has been developed, allowing pressure based feedback. A solenoid valve and a loudspeaker served as fuel and pressure actuators, respectively. By applying fuel actuation, relations to industrial relevance are taken into consideration. Experiments confirm the general view within the combustion control community that actuator design is a significant challenge and limitation for the success of active combustion control. Successful damping of the combustion oscillations was shown using various different control design methods. Figure 5.11 illustrates an experiment, where the main resonance is damped by the order of 12 dB and the pressure variance is damped by 60%. The experiments show the potential of active control in a combustion chamber.

The dynamics of the various different configurations of the combustion chambers were modeled using both analytical methods and system identification methods. System identification exhibits a high potential to application in more sophisticated, industrial combustion chambers.

On December 20, 2005 and within this project, Martin A. Kjær completed his licentiate thesis entitled “Active Stabilization of Thermoacoustic Oscillation”.

Decentralized Structures for Industrial Control

Researchers: Pontus Nordfeldt, Tore Hägglund

There is an unfortunate gap between the centralized computational approaches of multi-variable control theory and the common practice to design local control loops disregarding couplings and interaction. Today it appears that both approaches has reached a point of refinement where the gap can be reduced from both sides.

This project aims to revise and improve the basic modules for decentralized control, and to develop new. By increasing the performance of the modules, the usefulness of present MIMO control functions such as MPC will increase. In this way, we will try to decrease the gap between MIMO control functions and the state of the art of process control. The ideas to be investigated in this project are relevant not only for process control but is also of interest for general classes of multi-variable systems. In a first stage, we will develop a new module building on experiences from PID control: a TITO controller, i.e. a controller with two inputs and two outputs. To be accepted in process control, the TITO controller will be fully automatic without any parameters to be set by the user. It means that an automatic tuning procedure has to be developed.

In a first phase, a decoupling procedure and a new PID design method has been developed. The decoupler is dynamic, but the goal has been to introduce as little dynamics in the decoupler as possible. Traditional PID design methods are not suitable for decoupled systems. For this reason, a new design method based on exhaustive search has been derived.

The work in this first phase has resulted in a licentiate thesis by Pontus Nordfeldt.

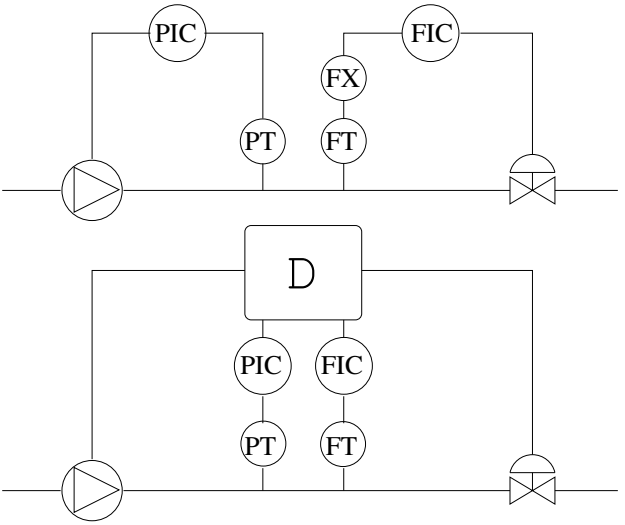

Figure 5.12 Conventional control of coupled systems (upper) and control with decoupling (lower).

Control and Diagnosis in Batch Processes

Researchers: Rasmus Olsson, Charlotta Johnsson, and Karl-Erik Årzén

The aim of this project is to study integrated information and control systems for batch production. Special emphasis is put on integration of the monitoring and supervision tasks with recipe-based production. Two main issues is under investigation. The first issue studies the interaction between recipe execution and supervision. A model-based approach is taken where an internal unit model is used to check the validity of the unit operations in the recipes on-line. The internal unit model will also be used to structure the representation of the basic interlocking logic for safety monitoring. The second issue concentrates on the use of historical data in monitoring and supervision of batch process.

The work in the first part of the project is a continuation of the work on recipe-based batch processes by Charlotta Johnsson. The work is based on JGrafchart, a graphical sequential programming language that and its applications to batch recipe management and resource allocation. The focus of this part of the project is to extend JGrafchart by adding different features that support exception handling in batch production. Our results have been applied to the PROCEL batch laboratory process at UPC. Our approach is integrated with the reactive batch scheduling software

developed at UPC. Part of this work is financed by the CHEM EU project.

The work in the second part is focused on how model-based methods diagnosis can be combined with multivariate statistical methods. During 2005 the main focus has been the completion of Rasmus Olsson's Ph.D. thesis that was defended on June 17 with Professor Sten Bay Jörgensen from DTU as the examiner.

Control of Biotechnology Processes

Researchers: Lena de Maré, Stéphane Velut, and Per Hagander in cooperation with Jan Peter Axelsson, Pfizer AB, and Olle Holst, Department of Biotechnology, Lund University

Large-scale production of many enzymes and pharmaceuticals can today be made using genetically modified microorganisms. In so called bioreactors, living cells are grown to large numbers and then made to produce the desired substance. Fed-batch operation, where additional substrate is fed to the culture, is often the preferred way of production. To achieve reproducible cultivations with high cell densities and high productivity, it is important to design good strategies for the substrate-dosage control. A characteristic feature of biological processes is that many important process variables are not easily measured on-line, which complicates the design and realization of feedback strategies.

A project on substrate-dosage control of fed-batch units with genetically modified *E. coli* is performed together with Pfizer. Information of how to change the substrate feed rate is obtained from standard dissolved oxygen measurements by introducing controlled process perturbations. Tuning rules are derived for the control strategy that assume a minimum of process specific information, and the system is analysed for stability using the theory for piecewise linear systems.

The strategy is implemented at many industries and research laboratories, and it is tested with different E. coli strains and also other organisms like bakers yeast and cholera bacteria. Good cultivation conditions and high production levels are in general obtained from the first experiments.

For the case when the oxygen transfer capacity of the reactor is reached, we have designed a method that combines the use of stirrer speed and temperature in a mid-ranging fashion instead of feed reduction to maintain the oxygen concentration at desired levels also during the production phase.

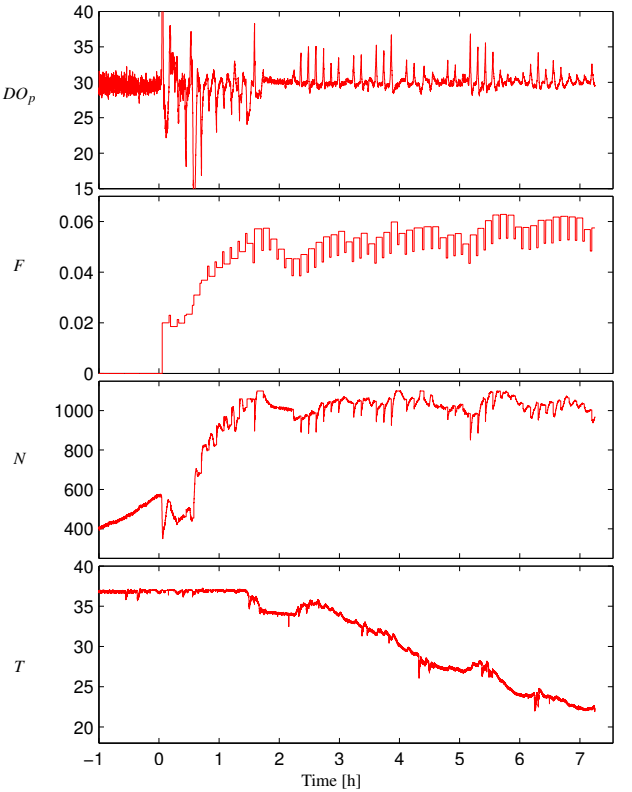

Figure 5.13 A cultivation using the new fermentation technique effective when the oxygen transfer capacity of the reactor is met with *E. coli* BL21(DE3). The fed-batch part of the cultivation is shown. From the top: $DO_p[\%]$, dissolved oxygen, $F[l/h]$ glucose feed rate, $N[rpm]$ stirrer speed and $T[°C]$ temperature.

During 2005 Stéphane Velut completed his Ph.D. thesis that was defended on June 3 with Professor Frank Allgöwer from Stuttgart as the examiner.

Robotics

SMErobot

Researchers: Isolde Dressler, Rolf Johansson, Anders Robertsson, and Anders Blomdell in cooperation with Klas Nilsson, Dept. Computer Science; Karl. Åström, Rikard Bertilsson, Fredrik Kahl, Dept. Mathematics, Lund University, and Dr. Torgny Brogårdh, ABB Robotics.

SMErobot is an EU/NMP FP6 integrated project lead by Fraunhofer - Institut fűr Produktionstechnik und Automatisierung (IPA) and other project partners include GPS Gesellschaft für Produktionssysteme GmbH, Pro-Support B.V., ABB Automated Technologies Robotics, COMAU S.p.A., KUKA Roboter GmbH, Reis Robotics GmbH & Co. Maschinenfabrik, Güdel AG, Casting technology International LTD by Gurantee, Visual Components Oy, Rinas ApS, SMEEIG EESV, Prospektiv Gesellschaft f. betriebliche Zukunftsgestaltung GmbH, Fraunhofer - Institut f. Produktionstechnik und Automatisierung (IPA), German Aerospace Center - Institute of Robotics and Mechatronics, University of Coimbra / ADDF, Istituto di Tecnologie Industriali e Automazione, Fraunhofer - Institut f. Systemtechnik und Innovationsforschung (ISI).

The need More than 228 000 manufacturing SMEs in the EU are a crucial factor in Europe's competitiveness, wealth creation, quality of life and employment. To enable the EU to become the most competitive region in the world, the Commission has emphasized research efforts aimed at strengthening knowledge-based manufacturing in SMEs as agreed at the Lisbon Summit and as pointed out at MANUFUTURE-2003. However, existing automation technologies have been developed for capital-intensive large-volume manufacturing, resulting in costly and complex systems, which typically cannot be used in an SME context. Therefore, manufacturing SMEs are today caught in an 'automation trap': they must either opt for current and inappropriate automation solutions or compete on the basis of lowest wages. A new paradigm of affordable and flexible robot automation technology, which meets the requirements of SMEs, is called for.

Breakthrough This initiative is intended to exploit the potentials of industrial robots, because they constitute the most flexible existing automation technology. The consortium is set to create a radically new type of robot system - a whole family of SME-suitable robots.

Objectives The SMErobot initiative offers an escape out of the automation trap through:

- Technology development of SME robot systems adaptable to varying degrees of automation, at a third of today2̆018s automation life-cycle costs;
- New business models creating options for financing and operating robot automation given uncertainties in product volumes and lifetimes and to varying workforce qualification.
- Empowering the supply chain of robot automation by focusing on the needs and culture of SME manufacturing with regard to planning, operation and maintenance.

Innovations Research and development in SMErobot is geared towards creating the following technical innovations:

1. Robot capable of understanding human-like instructions (by voice, gesture, graphics)
2. Safe and productive human-aware space-sharing robot (cooperative, no fences)
3. Three-day-deployable integrated robot system (modular plug-and-produce components)

Partners Five major European robot manufacturers have joined forces in SMErobot, in close cooperation with key component manufacturers, five leading research institutes and universities, and consultants for multidisciplinary RTD, dissemination and training efforts.

Implementation Demonstrations of fully functional prototypes will be set up in different SME manufacturing branches (plastics & rubber, small-batch foundry, metal parts fabrication, etc.), together with SME end users and SME system integrators, partly from the new Member States. Training and education will be conducted at all levels from researcher to end-users.

Integration SMEs and society benefit from the combined integration of knowledge along the supply chain of robotic automation, from component manufacturers to end users, from multidisciplinary activities to business/financing models, and from fundamental technical research when confronted with SME scenarios. Management includes dedicated support for SME integration.

Flexible and Accurate Manufacturing Operations Using Robot Systems

Researchers: Anders Blomdell, Mathias Haage, Rolf Johansson, Klas Nilsson, Tomas Olsson, and Anders Robertsson, Lund University in cooperation with Mats Björkman, Henrik Kihlman, and Gilbert Ossbahr, IKP, Linköping University.

This projects deals with a feasibility study is of flexible and accurate manufacturing operations using robot systems with interactions sensors such as work-space force sensing. The goal of the project is to develop methodology and hardware support for improved high-precision operations and functionality for fast off-line programming based upon computer-aided design. Five companies and two university partners participate in this project financially supported by SSF.

The need for flexibility today often motivates the use of robots within manufacturing, which works well for many standard applications. However, both deficient absolute precision (for non-compliant motions) and lack of control of the applied contact force (between tool and work-piece for compliant motions) severely limits the applicability today. Another key problem within flexible manipulation is that fixtures are needed but they are not flexible. In total, considering cost and productivity, the experienced implication is that robots do not really help short-series production in Swedish industry today.

Based on standard industrial robots, enhanced with new types of sensing and control interfaces, we propose an interdisciplinary research effort to improve the flexibility of flexible automation. Based on recent scientific advances and industrial results within ongoing European research projects, we have found opportunities to create robot systems with capabilities that go well beyond what is available and affordable today.

One of the basic ideas is to make use of the latest developments in industrial metrology and manufacturing simulation techniques, to drastically improve precision. A second basic idea is to combine the robot with the unique low-cost flexible fixture technology of the Adfast (EU FP5) project, providing automatic fixture set-up for precision assembly/machining/measurements and avoiding today2019s large investments in product specific equipment. A third idea is to make use of end-effector force/torque sensing for force-controlled motions, maintaining accurate position control in some directions but accepting compliance and deviations in other directions as required for the task at hand.

An enabling factor for our ideas is the availability of an industrial robot system that has superior capabilities in terms of feedback from external

sensors to the built-in motion control system. Based on the last ten years of research within open control systems for industrial robots at LTH, the core of such a system has been developed within the Autofett (EU FP5) project as a joint effort between ABB and LTH, and the resulting system is successfully being tested in Holland and in the USA.

More specifically the objective of this project is to deliver: A standard industrial robot that via an embedded metrology system will achieve a high absolute accuracy (< 0.1 mm) in several applications. A standard industrial robot that via force sensing and feedback control will achieve compliant motion in certain directions as required within typical applications like grinding and debarring. A robotic research platform enabling other groups/projects to explore the possibilities of low-cost sensing to improve flexibility within a larger variety of applications, packaged as a research kit to be installed into new ABB robots. A task-oriented generic programming method that will increase the agility/flexibility of the robot and other flexible manufacturing equipment. The method will shorten the lead-time in the operation planning for the total manufacturing robot cell. Two functional demonstrators of end-user applications comprising improved robot system, simulation based operational planning and programming, flexible fixture application with robot-based machining

Automotive Systems

Diesel HCCI in Multi-cylinder Engines

Researchers: Maria Karlsson and Rolf Johansson in cooperation with Prof. Bengt Johansson, Dr. Per Tunestål, Div. Combustion Engines, Lund University, and Johan Bengtsson, Petter Strandh, Stefan Strömberg, Volvo Powertrain, Inc.

Homogeneous Charge Compression Ignition (HCCI) is a hybrid of the spark ignition and compression ignition engine concepts. As in an SI engine, a homogeneous fuel-air mixture is created in the inlet system. During the compression stroke the temperature of the mixture increases and reaches the point of autoignition, just as in a CI engine. One challenge with HCCI engines is the need for good timing control of the combustion. Auto ignition of a homogeneous mixture is very sensitive to operating condition. Even small variations of the load can change the timing from too early to too late combustion. Thus, a fast combustion timing control is necessary since it sets the performance limitation of the load control. This project deals with various approaches to feedback control of the HCCI engine for optimized fuel economy and low emissions. A 12-liter Volvo

Diesel engine has been successfully converted to HCCI operation with feedback systems based upon feedback of measured cylinder pressure or ion current. Among control methods successfully applied, linear quadratic Gaussian control and model-predictive control have been implemented and tested.

This project is financially supported by Volvo Powertrain, Inc., and the Vinnova PFF program.

Tire Models for Road Friction Estimation

Researchers: Jacob Svendenius, Magnus Gäfvert and Björn Wittenmark in cooperation with Haldex and Volvo Cars

The future trend for brake systems seems to be an exchange of pneumatics to electrical power for control and actuation. Use of electrical brakes results in a faster brake system with better controllability, but it also introduces new requirements in terms of reliability and safety thinking. The brake system is one of the most critical systems in the vehicle and new and different disturbances that can risk the safety will occur.

To make use of the possibilities brought by the new type of brake actuation more knowledge about the entire vehicle system is necessary. This system, which besides the electro mechanical objects and the dynamics of the vehicle also incorporates variable factors as the driving conditions and the road foundation. Adaptive control laws and identification of uncertain parameters are necessary tools to adjust for variations. This has lead the project into modeling of the tire and its interaction with the road. The main aspect is how to estimate the adhesion limits for the tire and road surfaces.

Preliminary tests have been performed on the test-track MIRA in England and in Arjeplog, Sweden, using test vehicle from Haldex, Landskrona. The tests show promising results. A major part of the work is performed in the IVSS-project “Road Friction Estimation” with the aim to examine the possibilities to develop and implement methods for detection of the road condition during driving.

The project is a collaboration between LTH, Haldex, Volvo Cars, Volvo AB, SAAB, VTI and LuTH and contains three sub-projects which deal with different approaches for road friction estimation. LTH, Haldex and Volvo Cars form one of the sub-projects, called “Modelbased Road-Friction Estimation”.

Figure 5.14 Test truck used for tests of friction estimation at Haldex

Semi-Empirical Tire Model for Combined Slip

Researchers: Jacob Svendenius, Magnus Gäfvert and Björn Wittenmark in cooperation with Haldex

Accurate tire models are necessary components of models aimed at analyzing or simulating vehicle motion in real driving conditions. With new active chassis-control systems that are based on unilateral braking it is increasingly important to describe the effects of combined braking and cornering correctly. A new easy-to-use tire-force model aimed at simulation of vehicle dynamics is developed for this purpose. The model is based on combining empirical models for pure braking and cornering with brush-model tire mechanics. The model can handle effects from camber and transient changes of the brake and cornering commands.

Complex Embedded Automotive Control Systems (CEmACS)

Researchers: Brad Schofield, Tore Hägglund, Anders Rantzer in cooperation with DaimlerChrysler AG, University of Glasgow, The Hamilton Institute and SINTEF

The overall aim of the CEmACS project is the development of active safety systems for road vehicles. Part of the work deals with the development of controllers for rollover prevention. Rollover accidents are a common and deadly form of vehicle accident, particularly for certain vehicle classes such as Sports Utility Vehicles (SUV) and light commercial vans, where the centre of gravity can be high. In the case of commercial vehicles, both the mass and the centre of gravity vary depending on the loading

Figure 5.15 DaimlerChrysler test vehicles, an A-class and S-500

conditions. This complicates the task of finding a controller to mitigate rollover.

Various systems for rollover prevention exist today in certain production vehicles, but they are rather simple. The aim of the project is to develop controllers capable of preventing rollover under all loading conditions without restricting vehicle performance unnecessarily. This requires the development of advanced methods of state estimation, parameter estimation and control design. Testing of controllers can be done in an advanced vehicle simulation environment as well as in various test vehicles maintained by DaimlerChrysler.

Biomedical Systems

Balance Laboratory

Researchers: Rolf Johansson in cooperation with Prof Måns Magnusson, Dr. Pera-A. Fransson and Dr. Mikael Karlberg (Department of Clinical Sciences, Div. Otorhinolaryngology, Lund University Hospital)

The project is directed towards assessment of normal and pathological human postural control. System identification and mathematical modeling of the dynamics in postural control are studied with special interest on adaptation, reflexive and anticipatory control. Reflexive and voluntary eye movements are studied in patients with lesions related to balance disorders. Experimental studies, with special reference to the level of alertness, are undertaken to enhance understanding, diagnosis and treatment of dizziness and vertigo. A major complication is that human postural control is characterized by multi sensory feedback control (vi-

sual, vestibular, proprioceptive feedback) and this fact is reflected both in experiment design and analysis. Special interest is directed to the importance of cervical and vestibular afferent pathways. To this purpose, stability properties are studied by means of induced perturbations specific to each sensory feedback loop by using system identification methodology. The work is supported by the Scientific Research Council (Grant 2004-4656: Quantification of human postural control, reflexive eye movements and development of therapies for disturbed balance and dizziness) and the Faculty of Medicine, Lund University.

On May 20, 2005, Per-Anders Fransson defended his PhD thesis entitled Analysis of Adaptation in Human Postural Control, (Ph.D. Thesis 2005:31), Dept Clinical Sciences, Lund University.

Cardiologic Analysis and Modeling

Researchers: Rolf Johansson in cooperation with Prof. S. Bertil Olsson, and Dr. Jonas Carlson, Dept. Cardiology, Lund University Hospital, Lund University.

This project is directed towards chronic atrial fibrillation (CAF), one of the most common cardiac arrhythmia's in man and associated with increased morbidity and mortality. Previous studies in animals have shown that experimental atrial fibrillation is based on different types of intra atrial electrical reentry. By exploring the activation of the right atrial free wall during open-heart surgery in patients with CAF and an underlying heart disease, we confirmed the presence of reentry mechanisms. In addition, areas with organised activation were identified. The nature of the organised activation suggested reentry in an anatomical structure, like the right annular bundle surrounding the tricuspid valve. In patients without signs of organised activation, multiple activation waves continuously reenter due to functional properties of the atrial myocardium. An interesting result was that we failed to demonstrate that anisotropy in conduction velocity be a general property of the epicardial right atrial free wall of the intact human heart in patients with stable sinus rhythm as well as in patients with CAF.

On December 9, 2005, Jonas Carlson defended his Ph.D. thesis entitled Exploration of Supra ventricular Conduction with Respect to Atrial Fibrillation, PhD Thesis 2005:106, Dept. Clinical Sciences, Cardiology, Lund University Hospital.

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External Contacts

A healthy mix of fundamental and applied work is a cornerstone of our activities. In the applications projects the goal is to solve real control problems together with external partners. In these projects the problems are approached with an open mind without glancing at particular methods. One purpose is to learn about real problems, another is to learn about new problems that are suitable for theoretical research.

An important role for universities is to organize knowledge in such a way that the results can easily be digested by engineers in industry. There is naturally a strong symbiosis with teaching in this activity. A good mechanism is thus to introduce new research material into existing and new courses. A related form of technology transfer is to write books and monographs and to develop software.

Exchange of personnel between industry and university is another very effective vehicle for technology transfer.

Industrial Contacts

We have very good working relations with many companies and organizations. The interaction are at different levels and intensities, from visits and discussions to joint projects. Master theses and education are also important ingredients. During the year we have had major projects with

ABB,
Assidomän Frövi,
Casting technology International LTD by Gurantee,
COMAU S.p.A.,
Gudel in Switzerland,
Fraunhofer-Institut (IPA und ISI) in Germany,

Güdel AG,
Haldex,
KPS Rinas in Denmark,
KUKA Roboter GmbH in Germany,
NFO Control AB,
Pro-Support B.V.,
Prospektiv Geschellschaft f. betriebliche Zukunftgestaltung GmbH,
Reis Robotics GmbH & Co. Maschinenfabrik,
Rinas ApS,
Scania CV AB,
Siemens,
Visual Components Oy,
Volvo.

European Collaboration

The department is involved in several projects in the 6th Frame Program of the European Commission.

FP6 Projects:

Networks of Excellence (NoE):

- ARTIST2 — Embedded Systems Design
- HYCON — Hybrid Control: Taming heterogeneity and complexity of networked embedded systems
- EURON-II — European Robotics Research Network

Integrated Projects (IP):

- RUNES — Reconfigurable Ubiquitous Networked Embedded Systems
- SMErobot — The European Robot Initiative for Strengthening the Competitiveness of SMEs in Manufacturing

Specific Targeted Research Projects (STREP):

- CEmACS — Complex Embedded Automotive Control systems

7

Dissertations

Two PhD theses were defended by Stéphane Velut and Rasmus Olsson; three Licentiate theses were completed by Staffan Haugwitz, Pontus Nordfeldt, and Martin Ansbjerg Kjær.

The abstracts are presented here in chronological order. PDF-documents of the theses are available at

http://www.control.lth.se/publications/.

Probing Control. Analysis and Design with Application to Fed-Batch Bioreactors

Stéphane Velut
PhD dissertation, June 3, 2005

Opponent: Prof. Frank Allgöwer, Institute for Systems Theory in Engineering, University of Stuttgart, Germany. Committee: Prof. Bo Egardt, Signals and Systems, Chalmers University of Technology, Gothenburg; Prof. Ulf Holmberg, School of Information Science, Computer and Electrical Engineering, Halmstad University, Sweden; Professor Svante Gunnarsson, ISY, Linköping University, Sweden.

In most control problems the objective is to control the output at a desired value in spite of disturbances. In some cases, the best set point is not known a priori and it should be found on line to optimize the process performance. This thesis examines a probing strategy that can be applied for this class of problems. The focus is on the application of the technique to the control of feed supply in fed-batch fermentations of the bacterium Escherichia coli. The thesis is divided into three parts.

In the first part, the convergence properties of the probing algorithm are examined. The analysis is limited to processes modeled by a linear time-invariant dynamic in series with a static nonlinearity. Stability and performance analysis taking into account the process dynamic is performed. Tuning guidelines that help the user for the design are also derived.

The second part presents a novel cultivation technique based on the probing approach. The fermentation technique combines the advantages of probing control and temperature-limited fed-batch technique. The feeding strategy is well adapted for prolonged operation at the maximum oxygen transfer capacity of the reactor. The efficiency of the method is demonstrated by simulations and experimental results. The strategy leads to a high biomass and it limits the degradation of the recombinant protein activity in the late production phase.

In the third part, the probing feeding strategy is evaluated in industrial-scale bioreactors. Based on experimental results the influence of scale and complex medium is discussed. It is shown that the flexibility and robustness of the technique makes it a useful tool for process development.

Batch Control and Diagnosis

Rasmus Olsson
PhD dissertation, June 17, 2005

Opponent: Professor Sten Bay Jørgensen, Department of Chemical Engineering, Technical University of Denmark. Committee: Professor Jan Eric Larsson, Dept. of Information Technology, Lund Institute of Technology, Sweden; Researcher Håkan Fridén, TFM, Mid Sweden University, Örnsköldsvik, Sweden; Engineer Bo G. Karlsson, Pfizer Healtch AB, Helsingborg, Sweden.

Batch processes are becoming more and more important in the chemical process industry, where they are used in the manufacture of specialty materials, which often are highly profitable. Some examples where batch processes are important are the manufacturing of pharmaceuticals, polymers, and semiconductors.

The focus of this thesis is exception handling and fault detection in batch control. In the first part an internal model approach for exception handling is proposed where each equipment object in the control system is extended with a state-machine based model that is used on-line to structure and implement the safety interlock logic. The thesis treats exception handling

both at the unit supervision level and at the recipe level. The goal is to provide a structure, which makes the implementation of exception handling in batch processes easier. The exception handling approach has been implemented in JGrafchart and tested on the batch pilot plant Procel at Universitat Politècnica de Catalunya in Barcelona, Spain.

The second part of the thesis is focused on fault detection in batch processes. A process fault can be any kind of malfunction in a dynamic system or plant, which leads to unacceptable performance such as personnel injuries or bad product quality. Fault detection in dynamic processes is a large area of research where several different categories of methods exist, e.g., model-based and process history-based methods. The finite duration and non-linear behavior of batch processes where the variables change significantly over time and the quality variables are only measured at the end of the batch lead to that the monitoring of batch processes is quite different from the monitoring of continuous processes. A benchmark batch process simulation model is used for comparison of several fault detection methods. A survey of multivariate statistical methods for batch process monitoring is performed and new algorithms for two of the methods are developed. It is also shown that by combining model-based estimation and multivariate methods fault detection can be improved even though the process is not fully observable.

Modeling and Control of the Open Plate Reactor

Staffan Haugwitz
Licentiate dissertation, September 2, 2005

Opponent: Dr. Krister Forsman, Perstorp AB, Sweden.

The focus of this thesis is on modeling and control of the Open Plate Reactor (OPR), a new heat exchange reactor being developed by Alfa Laval AB. It combines intensified mixing with enhanced heat transfer capacity into one operation. With the novel concept, highly exothermic reactions can be produced using more concentrated reactants, thus saving time and energy in the subsequent separation stage. To better utilize the reactor, reactants can be injected in multiple injection points and there are internal sensors for process monitoring and control. A flexible process configuration simplifies the adaptation of the reactor to new reactions in terms of residence time, cooling system, actuator and sensor locations. To take full advantage of the flexible configuration and the improved performance, a new process control system is presented. A nonlinear model of the reactor is derived from first principles. After steady-state and dynamic

analyses of the OPR, suitable control variables are chosen to allow flexible and accurate control of the reactor temperature and concentration. A Model Predictive Controller (MPC) is designed to maximize the conversion under hard input and temperature constraints. An extended Kalman filter estimates unmeasured concentrations and parameters, to increase the robustness to process variations. The MPC sends reference signals to local feedback controllers within a cascade control structure. To remove the generated heat from the reaction, a cooling system is designed and experimentally verified. For temperature control, a mid-ranging control technique is implemented to increase the operating range of the hydraulic equipment and to increase the robustness to disturbances. Dynamic simulation and optimization show that the designed control system leads to high conversion and ensures that the temperature inside the reactor does not exceed a pre-defined safety limit.

PID Control of TITO Systems

Pontus Nordfeldt
Licentiate dissertation, December 16, 2005

Opponent: Dr. Alexander Horch, AB Corporate Research, Ladenburg, Germany.

This thesis treats controller design and tuning for systems with two input signals and two output signals in the process industry. Two design methods that can be combined to form a core in an algorithm for automatic design and tuning for the considered systems are presented. The proposed controller consists of a decoupler and a diagonal PID controller. This implies that the two main problems to solve are those of how to design the decoupler and how to design the diagonal controller. The decoupling problem is treated in a general way in this thesis and a decoupler design method is proposed. A PID controller design method is also proposed. The method is based on exhaustive search, and a simple version of software for this is presented. The methods are combined and tested in both simulations and on a real process in an industrial environment.

Active Stabilization of Thermoacoustic Oscillation

Martin Ansbjerg Kjær
Licentiate dissertation, December 20, 2005

Opponent: Dr. Jan Tommy Gravdahl, NTNU, Trondheim, Norway.

Combustion processes serve as important sources of energy for both power generation and for transport, ranging from large scale power stations to micro turbines and aeroplane engines. Lean premixed combustion offers a potential to reduce the emission levels, but suffers from instability problems which can be overcome by the use of active control. This thesis addresses the problem of actively controlling thermo acoustic instabilities in a laboratory test combustion chamber. Different strategies for actuation are discussed and evaluated experimentally. Relations to industrial relevance are taken into consideration, and a fuel actuator is developed and implemented. Experiments confirm the general view within the combustion control community that actuator design is a significant challenge and limitation for the success of active combustion control. The dynamics of the different configurations of the combustion chambers is modeled using both analytical methods and system identification methods. System identification shows the best potential to be transfered to more sophisticated combustion chambers. Successful damping of the combustion oscillations is shown with different control design methods. The most convincing results are obtained with a Kalman filter based LQR control design.

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Honors and Awards

Rune Prytz Anderson and **Per Skarin** received the Bengt Asker Award for the Best Real-Time Master Thesis 2005 for their thesis “Memory Protection in a Real-Time Operating System”. The thesis was done in collaboration between the Department of Automatic Control, supervisor: Karl-Erik Årzén and Volvo Technology in Gothenburg.

Anders Blomdell, Mathias Haage, Rolf Johansson, Klas Nilsson, Tomas Olsson, Anders Robertsson from Lund University and **Torgny Brogårdh, Tomas Groth, Mats Isaksson, Stig Moberg, Sven Hanssen, Hui Zhang, Jian Jun Wang, Håkan Brantmark** from ABB received the *Euron Technology Transfer Award 2004*, Warszawa, February.

Anton Cervin was employed as a junior researcher (a four-year position) at Lund University by the Swedish Research Council (VR).

Staffan Haugwitz and **Per Hagander** received the *Best Control Application Paper Award* for their paper "Process control of the Open Plate Reactor" at the IFAC World Congress in Prague.

Anders Rantzer was one out of 12 Swedish scientists who received an *extended Senior Individual Grand* from the Swedish Foundation for Strategic Research.

Henrik Sandberg was selected as an *Outstanding Reviewer for the journal Automatica in the year 2005*.

Henrik Sandberg received a two-year post-doctoral grant from the Swedish Research Council (VR).

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Personnel and Visitors

Personnel

During 2005 the following persons have been employed at the department. The list shows the *status of December 2005* if nothing else is mentioned.

Professors

Karl-Erik Årzén
Karl Johan Åström (emeritus)
Bo Bernhardsson *(part time)*
Per Hagander
Tore Hägglund
Rolf Johansson
Anders Rantzer
Björn Wittenmark

Research Associates

Anton Cervin
Charlotta Johnsson
Anders Robertsson

Researchers

Henrik Sandberg

Research Engineers

Leif Andersson
Anders Blomdell
Rolf Braun

PhD Students

Johan Åkesson *(on leave until August)*
Peter Alriksson
Martin Andersson
Johan Bengtsson *(until March)*
Lena de Maré *(on leave until March, and from October until December)*
Isolde Dressler
Jenny Ekvall
Olof Garpinger *(from August)*
Ather Gattami
Staffan Haugwitz
Dan Henriksson
Maria Karlsson *(from August)*
Martin A. Kjær
Oskar Nilsson
Pontus Nordfeldt
Rasmus Olsson *(until September)*
Tomas Olsson
Toivo Perby Henningsson *(from August)*
Mikael Petersson
Brad Schofield
Ola Slätteke
Jacob Svendenius
Stéphane Velut
Andreas Wernrud

Secretaries

Britt-Marie Mårtensson
Eva Schildt
Agneta Tuszyński

Visiting Scientists

The following researchers have stayed with the department for a couple of days by the least.

Jonathan Chauvin *September 5–November 30, 2005*
Ecole de Mines, Paris, France

Sebastián Dormido Bencomo *April 24–April 30, 2005*
Universidad Nacional de Educación a Distancia, Madrid, Spain

Jon Gunther *August 2004–June 2005*
The University of Santa Barbara, USA. Fulbright Fellow for the 2004–2005 academic year

Pedro Garcia *August 8–September 23, 2005*
Polytechnical University of Valencia, Spain

Lars Grüne *September 26–29, 2005*
Universität Bayreuth, Germany

José Luis Guzmán Sánchez *September 1–December 1, 2005*
Universidad de Almería, Spain

Michal Kutil *May 9–June 30, 2005*
Czech Technical University in Prague, Czech Republic

Manuel Lluesma *May 25–July 1, 2005*
University of Valencia, Spain

Rocco Lombardi *October 18–November 30, 2005*
National Council of Research, Bari, Italy

David Mannone *October 10–November 20, 2005*
National Council of Research, Bari, Italy

Stephen Prajna *July 9–July 30, 2005*
California Institute of Technology, Pasadena, CA, USA

Anton Shiriaev *August 29–August 31*
Umeå University, Umeå, Sweden

Antonio Tedone *November 9–December 21, 2005*
National Council of Research, Bari, Italy

Changming Yin *December 8, 2005–August 31, 2006*
Changsha University of Science, Hunan, China

Visiting Students

The following foreign students from the ERASMUS program, have stayed with the department and have made their master's theses.

Michael Attinger *until February*
Technische Hochschule Stuttgart, Germany

Julien Bertholino *from July 2004 - Not finished*
Grenoble Institut National Polytechnique de Grenoble, France

Jaume Correra Ripoll *from October*
Universitat de Girona, Spain

Simone Del Favero *from October*
Universita degli studi di Padora, Italy

Mathieu Gerard *from September*
Université de Liége, Belgium

Jens Graf *until March*
Technische Hochschule Darmstadt, Germany

Rosa Castañé *from August*
Universitat Politecnica de Catalunya, Spain

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Staff Activities

This is a short description of the staff (listed in alphabetic order) and their activities during the year. Publications and lectures are listed in separate sections.

Åkesson, Johan

Lic Tech, graduate student since January 2001. Johan's main research interest is in the field of languages for dynamic optimization of large scale systems. Johan's research interests also include stabilization of unstable systems subject to input saturation. During 2005, Johan was on paternal leave from January 2005 to September 2005. During the year, Johan was a teaching assistant in the courses Real Time Systems and co-supervised a master's thesis project; "Model based grade change support" in collaboration with Assidomän Frövi.

Alriksson, Peter

MSc graduate student since June 2003. His research interests are in estimation and optimal control of hybrid systems. Also some work have been done in the area of distributed estimation. His teaching responsibilities include beeing a teaching assistant in the courses Nonlinear Control, Control Theory, International Project Course and Automatic Control (Basic Course). Peter has also been co-supervising a master theises started in November 2005.

Andersson, Leif

MSc, Research Engineer since 1970. Leif started at the department with a responsibility for the teaching laboratory. He designed some lab equipment, notably an analog computer. In 1976 he started in ernest with digital computers, and has been responsible for the department computing facilities since then. His professional activities, apart from

computer system maintenance, have ranged from computer typesetting (TEX and LATEX) via Real Time Programming to using Java as a tool for writing educational software.

Andersson, Martin

Msc, graduate student since September 2003. Martins research interests concern design and analysis of realtime control systems and networked embedded systems. He is involved in ARTES++, RUNES and ARTIST2. Martin has been a teaching assistant in the Real-Time Systems course and in the course Control for InfoCom.

Årzén, Karl-Erik

Professor (2000), PhD (1987): Joined the department in 1981. His research interests are real-time control, real-time systems, programming languages for control, Petri nets and Grafcet, and monitoring and diagnosis.

Project director the SSF/FLEXCON project on flexible embedded control systems. Leader for the cluster on control for embedded systems withoin the EU/IST FP6 network of excellence ARTIST2 on design of embedded systems. During the year he has primarily been involved in the EU/IST FP6 IP project RUNES (Reconfigurable Ubiquitous Networked Embedded Systems) and in the SSF/FLEXCON project. He has been responsible for and taught the undergraduate course on Real-Time Systems and the International Project Course in Automatic Control. He is partly or fully involved in the supervision of three PhD students.

Bernhardsson, Bo

PhD 1992, Docent in 1988, and Professor in December 1999. Since 2001 Bo is on leave working at Ericsson Mobile Platforms in Lund and is working part time at our department.

Blomdell, Anders

Research Engineer since 1988. Responsible for the department network and lab computers for teaching and research. Professional interest includes man-machine interaction, real-time programming, hardware design, network communication protocols, and computer languages for control engineering.

During the previous years, Linux has been deployed on many different systems in hope of replacing the legacy STORK Real Time Kernel, which is now only used in m680x0 and PowerPC systems.

Braun, Rolf

Research Engineer at the department since 1969. Designs and builds equipment for education and research, and handles hardware maintenance of computers and equipment. He also plans and supervises maintenance and rebuilding of offices and labs.

Cervin, Anton

Research associate, PhD (2003); joined the department in 1998. Anton's research interests include real-time systems, networked control systems, and computer tools for analysis and simulation of controller timing. During 2005, he has been involved in the EU/IST/FP6 projects RUNES (Integrated Project on Reconfigurable Ubiquitous Networked Embedded Systems) and ARTIST2 (Network of Excellence on Embedded Systems Design). As Chairman of SNART, he was one of the organizers of the conference Real Time in Sweden 2005 in Skövde in August. He has also been a lecturer in the basic control course for the information and communication engineering students.

de Maré, Lena

MSc, graduate student since August 1999. She is interested in control of biotechnical processes and is working together with Stéphane Velut and Per Hagander in the project 'Process control for cultivation of genetically modified micro-organisms' funded by Vinnova.

Dressler, Isolde

MSc, graduate student since September 2004. Isolde is interested in modeling and control of parallel kinematic robots and works within the SMErobot project. She was teaching assistant in the basic Automatic Control and the Systems Engineering course.

Ekvall, Jenny

Lic Tech in November 2004, graduate student since January 2002. The process Jenny studies is the drying section of a paper machine. In collaboration with M-real, Husum, she models the drying section. She also evaluates different control strategies with purpose to improve moisture control.

Jenny is employed by Mid Sweden University and she is part of the research group NPI (Network for Process Intelligence) in Örnsköldsvik, where she also has her office.

Garpinger, Olof

MSc, graduate student since August 2005. In the spring of 2005 Olof finished his Master Thesis, on Modeling and Shape Control of large deformable telescope mirrors, at Lund University. This was a part of the research on the Extremely Large Telescope concept EURO 50, which is currently under development at Lund Observatory and some other Universities around the world. During the autumn, Olof has been teaching assistant in the basic Automatic Control course. His research topic is yet to be decided in 2006.

Hagander, Per

Professor, PhD (1973). Per has been with the department since 1968 and works with linear system theory and with applications in biotechnology and medicine. Per is the LTH vice rector of international affairs.

During 2005 he taught the new course Control Theory and the PhD-course Linear Systems.

He is leading a project with Pfizer AB, on multivariable control of genetically engineered *E. Coli*. The work is also a collaboration with the Department of Biotechnology, Lund University and Novozymes Biopharma.

A new project on the control of a special type of continuous chemical reactors was started together with Alfa Laval AB within the Center for Process Design and Control (CPDC). The project is partially funded by EU-FP6 HYCON, WP4b.

Haugwitz, Staffan

Lic Tech, graduate student since August 2002. Staffan is working with Per Hagander on the project "Control of the Open Plate Reactor". The project is centered around the novel heat exchange reactor and the focus is to develop new control methods to take advantage of the flexible configuration of the reactor and to be able to use its full potential. In September, Staffan presented his Licenciate thesis.

Staffan was teaching assistant in the Computer-Controlled Systems course during the spring and in the Process Control course during the the fall .

Hägglund, Tore

Professor, PhD (1984). Has been at the department since 1978 except for four years when he worked for Alfa Laval Automation AB (now ABB). He is responsible for two of the basic courses in Automatic Control in the

engineering program. His main research interests include process control, PID control, adaptive control, supervision, and detection.

Main research activities during the year have been design of PID controllers, decentralized control structures, and research projects in collaboration with the pulp and paper industry.

Henningsson Perby, Toivo

MSc, graduate student since August 2005. During the autumn he has submitted an article based on his master's thesis to MTNS, done some low level programming for the parallell robot project, taken courses and been a teaching assistant in the basic Automatic Control course.

Henriksson, Dan

Lic Tech in December 2003, graduate student since December 2000. Dan's research interests concern analysis, design, and simulation of real-time control systems, and he is involved in the SSF/ARTES++ project "Flexible Embedded Control Systems" (FLEXCON). During 2005 Dan has been teaching the courses Projects in Automatic Control and Real-Time Systems.

Johansson, Rolf

Professor, MD, PhD. Active at the department since 1979. Rolf Johansson's research interests are in system identification, robotics and nonlinear systems and automotive control. He is node leader for the research projects SMErobot, HYCON, SSF ProViking FlexAA, Vinnova PFF Diesel HCCI and CECOST Gas Turbine. He is coordinating director for Robotics Laboratory with cooperation partners from Dept Computer Science, Dept Mechanical Engineering, Dept. Mathematics and industrial partners. He has industrial cooperation with ABB Robotics, Volvo Powertrain, Volvo Car Corporation and Scania CV AB. He is responsible for the two courses FRT041 System Identification and FRT050 Adaptive Control. Together with Dr. Måns Magnusson he leads research at the Vestibular Laboratory, Dept. Otorhinolaryngology, Lund University Hospital. During July 2005, he was invited to visit Universidad de Jaén, Jaén, Spain.

Charlotta Johnsson

Charlotta Johnsson holds a position as a Senior Research Associate. Her research is focused on Batch Control Systems and Manufacturing Operations System. Charlotta got her Ph.D. degree at the Department, in March 1999, with the thesis "A Graphical Languages for Batch Control".

After dissertation, Charlotta joined Orsi Automatzione S.p.A., later part of Siemens A&D, and worked in Genoa, Italy for 4.5 years.

At the department, Charlotta is responsible for two undergraduate courses; Automatic Process Control for Chemical Engineering and Biochemical Engineering, and Systems Engineering for Environmental Engineering and Engineering Nanoscience. Charlotta is also co-responsible for the course Technology, Strategy and Structure, given for the students at the Technology Management program.

During the year, Charlotta acted as examinator for one master thesis project.

Karlsson, Maria

MSc, graduate student since August 2005. She has devoted her time to course work and teaching. The teaching activities include supervising laboratory exercices in the basic control course and developing quantitative problem solving sessions for a new course on Systems Biology to be offered by the biology departments at Lund University.

Kjær, Martin Ansberg

Lic Tech, graduate student since August 2003. He is working in the field of active control of combustion instabilities together with Professor Rolf Johansson. During the last year he has been focusing on experimental research. He defended his Licentiate thesis on December 20, 2005. His teaching activities are related to the basic automatic control course for environmental engineering and nano-technology students and the more advanced adaptive control course.

Mårtensson, Britt-Marie

Secretary at the department since 1974. She is responsible for the department library, ordering books, handles the mail and office supplies. Assistant Webmaster. She handles the contact with printing offices for dissertations and other publications. Britt-Marie is also the department's service-person.

Nilsson, Oskar

Msc, graduate student since September 2003. Oskar is working together with Anders Rantzer in a project funded by Toyota Motor Corporation. His research is currently focused on model reduction of automotive models implemented in Dymola.

Olsson, Tomas

Lic Tech, graduate student since December 2001. His main research interests are robotic force control and high-speed vision-based tracking and control. He is working with industrial force control and applications of vision-based control in the SSF/ProViking project FlexAA. During the year he has been a teaching assistant in the courses Real-Time Systems and Projects in Automatic Control.

Rantzer, Anders

Professor of Automatic Control since 1999. Joined the department in 1993 after a PhD at KTH 1991 and a post-doc position at IMA, University of Minnesota. He has broad interests in modeling, analysis and synthesis of control systems, with particular attention to uncertainty, optimization and distributed control.

Anders Rantzer is the main supervisor for seven PhD students. He was spending the academic year 2004/05 as visiting research associate at California Institute of Technology. Some of the PhD students joined him at Caltech part of the time. After returning from the sabbatical, he also resumed his duties as department chairman. He served on international editorial boards during the year and was chairman of the evaluation committee in Signals and Systems for the Swedish Research Council.

Robertsson, Anders

Docent (2005), Research Associate (May 2003), PhD (1999). His main interest is in nonlinear control and robotics. Currently he is working on sensor-data integration and force control of industrial robots in collaboration with ABB Robotics. The research has been conducted with the LUCAS project and the Robotics Lab. He has also been doing research on admission control systems in network nodes in cooperation with the Department of Telecommunications, LTH. He has lectured the courses on Nonlinear Control and Servo Systems and Mathematical Modelling for engineering students and acted as advisor for 3 PhD students and several Master's Thesis projects.

During the year he has made a couple of research visit with Prof. Anton Shiriaev at the Dept. of Applied Physics and Electronics, Umeå University, a teacher exchange within the Erasmus programme to IFMA, Clermont-Ferrand, France, and a shorter visit to the Robotics Lab in Valencia, Spain, with Dr. Angel Valera.

In June 2005 he was appointed as "Docent" at the Department of Automatic Control, LTH.

Sandberg, Henrik

PhD in December 2004. Henrik has been at the department since January 2000. Henrik's research interests include modeling, model reduction, and linear systems. During 2005 he was lecturer in the course Computer-Controlled Systems and was teaching assistant in the course Control Theory. He was also a visiting researcher for a month at the Research School of Information Sciences and Engineering at the Australian National University in Canberra.

Henrik left the department in August, and is now a postdoctoral scholar with Control and Dynamical System at California Institute of Technology in Pasadena, USA.

Schildt, Eva

Secretary at the Department since 1970. Eva is mainly responsible for the financial transactions of the department such as bookkeeping and reporting to our sponsors. She handles the personnel administration and takes care of the administration concerning visitors at the department.

Schofield, Brad

MSc (2003). Graduate student since August 2003. He is involved in the EU STREP project Complex Embedded Automotive Control Systems (CEmACS) which deals with the development of active safety systems for road vehicles. Brad's work on the project involves the design of control systems for the prevention of vehicle rollover accidents. The project work is carried out in close cooperation with DaimlerChrysler AG, as well as several European universities and research institutions. During 2005, Brad was a teaching assistant in the System Identification and Adaptive Control courses.

Slätteke, Ola

Lic Tech in October 2003, graduate student since January 2001. Employed by ABB Automation Technologies as an industrial PhD-student. His work is focused on modeling and control of the drying section of a paper machine within the CPDC-project. Ola also has a few years of experience of the pulp and paper industry, working at Stora Enso Nymölla AB as a control engineer.

Svendenius, Jacob

Lic Tech since november 2003 and M Sc in mechanical engineering since 1998. He worked for three years in the laboratory at Haldex Brake Products with performance testing of brakes for heavy vehicles. 2001 he started as a PhD student at the department in a project together with Haldex concerning braking control and tire modeling. Jacob is involved in the IVSS-project "Road Friction Estimation" with the aim to develop methods for dectection of the road condition during driving.

Tuszyński, Agneta

Secretary at the department since 1981. She is responsible for registration of the student's course entries and exam results, and supervises the invoice payments from the department. She works with word processing in LaTeX. Agneta is also responsible for Activity Report 2005 together with Anton Cervin.

Wernrud, Andreas

MSc, graduate student since March 2003. His research interests are in optimal control and hybrid systems, with a focus on computational methods. He is involved in the HyCon-project, control and analysis of hybrid systems. During the year he has also been a teaching assistant in the course Adaptive Control.

Wittenmark, Björn

Professor in Automatic Control since 1989. He joined the department in 1966 and took his PhD in 1973. His main research interests are adaptive control, sampled-data systems, and process control. He is currently working within projects in the area of process design and control and control of communication networks. Since March 1, 2003 he is appointed as Assistant vice-chancellor (Vice president) of Lund University.

External Assignments

Opponent and Member of Examination Committee

Karl-Erik Årzén: External reviewer of the Licentiate thesis by Mikael Åkerholm, Department of Computer Science and Engineering, Mälardalen University, February 18. Member of the examination board of the Ph.D thesis by Josef Nedstam, Dept of Communication Systems, Lund University, December 8.

Per Hagander: External examiner on the PhD-thesis by Juan Yuz Eissmann, University of Newcastle, November 2005. Member of examination board of Bengt Johansson, Industrial Automation, Lund University, Lund, Sweden, January 12. Member of examination board of Per Borgquist, Chemical Engineering, Lund University, Lund, Sweden, February 4. Member of examination board of Hördur Haraldsson, Chemical Engineering, Lund University, Lund, Sweden, March 11.

Rolf Johansson: Member of examination committee of the thesis by Inés Romero Navarro, Dynamic Power System Load - Estimation of Parameters from Operational Data, Dept. Industrial Electrical Engineering and Automation, Lund University, Lund, Sweden, May 4, 2005. Roland Lenain, Contribution à la Commands de Robots Mobiles en Présence de Glissement, Université Blaise Pascal & Cemagref & IFMA, Clermont-Ferrand, France, November 14, 2005. Rapporteur officiel.

Anders Rantzer: Member of PhD thesis committee for Stephen Prajna, January 14 at California Institute of Technology, USA. Member of PhD thesis committee for Antonis Papachristodoulou, January 25 at Caltech, USA.

Anders Robertsson: Faculty Opponent of Licentiate thesis by Magnus Evestedt, Uppsala, December.

Board Member

Karl-Erik Årzén: Member of the Education Board of Computer Engineering and Communications Engineering, Lund University. Member of the Board of the SSF Graduate School on Chemical Process Design and Control (CPDC).

Anton Cervin: Board Member and Chairman of SNART (the Swedish National Real-Time Association).

Tore Hägglund: Member of the Education Board of Engineering Physics, and the Appointment Board for FIME - physics, informatics mathematics and electrical both at Lund Institute of Technology. Expert member in legal proceedings for patent at Svea Court of Appeal, 2004–2006.

Rolf Johansson: Member of SMErobot Scientific and Technical Advisory Board.

Charlotta Johnsson: Board member of WBF(the Forum for Automation and Manufacturing Professionals) where she serves as Director of European Operations.

Anders Rantzer: Chairman of the evaluation committee on Signals and Systems at the Swedish Research Council. Member of the steering committee for the International Symposium on Mathematical Theory of Networks and Systems. Member of the Administrative Council for the European Union Control Association.

Björn Wittenmark: Assistant vice-chancellor (Vice president) for Lund University from March 1, 2003. Chairman of the Board of Campus Helsingborg. Board member of LUCAS. Expert member in legal proceedings for patent at Svea Court of Appeal, 2004-2006.

Book and Journal Editor

Rolf Johansson: Assoc. Editor Int. J. Adaptive Control and Signal Processing.

Tore Hägglund: Associate editor for Control Engineering Practice.

Anders Rantzer: Member of the editorial board for International Journal of Robust and Nonlinear Control.

Björn Wittenmark: Reviewer for research evaluations for the Swedish Research Council, Australian Research Council, Norwegian Research Council, and Italian National Research Council. Optimal Control Applications & Methods, Journal of Forecasting, IEE Proceedings Control Theory & Applications, and International Journal of Adaptive Control and Signal Processing.

Advisory Committees and Working Groups

Karl-Erik Årzén: Member of the IFAC Technical Committee on Chemical Process Control Vice chair of the IFAC Technical Committee on Computers and Control.

Per Hagander: Member of IFAC Technical Committee BIOMED. Member of IFAC Technical Committee Biotechnological Processes. Member of ESBES - Working group M^3C.

Tore Hägglund: IFAC Technical Committee on Adaptive and Learning Systems.

Rolf Johansson: Member of IEEE EMBS Technical Committee (TC) for Biomedical Robotics. Member of Joint EMBS/RAS Advisory Committee on Biorobotics.

Charlotta Johnsson: Educational Chair of ISA District 12 (Europe, Middle East, Africa and Russia). Charlotta is a voting member in the standardisation committee ISA 95, and an information member in the standardisation committees ISA 88 and ISA 99. Charlotta is a member in SEK and serves as the Swedish expert in the international IEC and ISO workinggroup JWG15.

Björn Wittenmark: Chairman of the committee for IFAC Control Engineering Practice Price. Member of the Technical Committee for IFAC Adaptive Control and Learning. Member of the IEEE Control System Society International Affairs Committee. Member of the IEEE Control Systems Society George S. Axelby Outstanding Paper Award Committee.

Anders Rantzer: Member of the Advisory Board for Lecture Notes in Control and Information Sciences at Springer Verlag Heidelberg. Member of the IEEE Control System Society Technical Committee on Nonlinear Systems and Control. Member of the IFAC Technical Committee on Nonlinear Systems. Member of the organizing committee of the Second China-Sweden Conference on Control.

Anders Robertsson: Members of the Swar'05 Program Committee (Swedish Workshop on Autonomous Robots).

Member of International Program Committee (IPC)

Karl-Erik Årzén: Chairman of the IPC for RTC2005: 1st International ECRTS Workshop on Real-Time Control, Mallorca, June 2005. Member of the IPC for ECRTS'05 (Euromicro Conference on Real-Time Systems), Mallorca, June 2005. Member of the IPC for Special Session on Model Driven Engineering at 31th Euromicro Conference, Porto, September 2005. Member of the IPc for the 14th International Workshop on Parallel and Distributed Real-Time Systems (WPDRTS 2006), Rhodes, Greece, April 2006.

Anton Cervin: Member of the IPC for the 11th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA'05). Program Chair for Real Time in Sweden 2005 – the 8th Biennial SNART Conference on Real-Time Systems.

Tore Hägglund: Member of the International Program Committees for the conferences Controlo 2006 - 7th Portuguese Conference on Automatic Control in Lisbon, Portugal, 2006 IEEE Symposium on Computer-Aided Control Systems Design (CACSD6) in Munich, Germany.

Rolf Johansson: IPC Member of IEEE 2005 American Control Conference, Portland, Oregon, June 2005. IPC Member of 2005 IEEE Symposium on Computational Intelligence in Robotics and Automation, Helsinki, Finland June 27-30, 2005. IPC Member of 2005 IEEE International Conference on Robotics and Automation (ICRA2005), April 18-22, 200, Barcelona, Spain. IPC Member of ICCV Workshop on Dynamical Vision, Tenth Int. Conference on Computer Vision (ICCV 2005), Beijing, China, October 15-21, 2005.

Anders Rantzer: Member of the IPC for European Control Conference 2007 (ECC07). Member of the IPC for 2nd IFAC Conference on Analysis and Design of Hybrid Systems (ADHS06). Member of the IPC for 7th IFAC Symposium on Nonlinear Control Systems (NOLCOS07).

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Publications and Conference Contributions

This year 2 books, 7 book contributions, 15 journal papers, and 32 conference papers have been published.

Books

Andler, Sten F., and Anton Cervin, Eds.: *RTiS 2005 – Proceedings of Real Time in Sweden 2005, the 8th Biennial SNART Conference on Real-Time Systems*. Skövde University Studies in Informatics 2005:1, August 2005. ISSN 1653-2325, ISBN 91-631-7349-2.

Åström, Karl Johan, and Tore Hägglund: *Advanced PID Control*. ISA - The Instrumentation, Systems, and Automation Society, Research Triangle Park, NC 27709, 2005.

Book Contributions

Årzén, Karl-Erik, Anton Cervin, and Dan Henriksson: "Implementation-aware embedded control systems." In Levine and Hristu-Varsakelis, Eds., *Handbook of Networked and Embedded Control Systems*. Birkhäuser, 2005.

Collado, J., R. Lozano, and Rolf Johansson: "Observer-based solution to the strictly positive real problem." In Astolfi, Ed., *Nonlinear and Adaptive Control, Tools and Algorithms for the User*. Imperial College Press, London, December 2005.

Johansson, Rolf: "z-Transform and digital systems." In Dorf, Ed., *The*

Engineering Handbook (2nd Ed.), Chapter 105. CRC Press, Boca Raton, FL, 2005.

Prajna, Stephen, and Anders Rantzer: "Primal dual tests for safety and reachability." In *8th International Workshop on Hybrid Systems: Computation and Control*. Springer, Berlin, March 2005. ISBN 3-540-25108-1.

Strandh, Petter, Johan Bengtsson, Rolf Johansson, Per Tunestål, and Bengt Johansson: "Variable valve actuation for timing control of a homogenous charge compression ignition engine." In *Homogeneous Charge Compression Ignition (HCCI) Combustion 2005*, vol. SAE SP-1963 of *SAE Special Publication*. SAE, Warrendale, PA, March 2005. ISBN 0-7680-1608-8, pp. 301-310.

Svendenius, Jacob, and Magnus Gäfvert: "A semi-empirical tire model for combined slips including the effects of cambering." In Lugner and Plöchl, Eds., *Tyre Models For Vehicle Dynamics Analysis*, vol. 43. Taylor & Francis Group, Glasgow, August 2005.

Velut, Stéphane, and Per Hagander: "Control of fed-batch bioreactors. part II." In Astolfi, Ed., *Nonlinear and adaptive control: theory and applications for the users*. IC Press, 2005. To appear.

Journal Papers

Årzén, Karl-Erik, Anders Blomdell, and Björn Wittenmark: "Laboratories and real-time computing." *IEEE Control Systems Magazine*, **25:1**, pp. 30–34, February 2005.

Åström, Karl Johan, Richard E. Klein, and Anders Lennartsson: "Bicycle dynamics and control." *IEEE Control Systems Magazine*, **25:4**, pp. 26–47, August 2005.

Blomdell, Anders, Gunnar Bolmsjö, Torgny Brogårdh, Per Cederberg, Mats Isaksson, Rolf Johansson, Mathias Haage, Klas Nilsson, Magnus Olsson, Tomas Olsson, Anders Robertsson, and Jianjun Wang: "Extending an industrial robot controller–Implementation and applications of a fast open sensor interface." *IEEE Robotics & Automation Magazine*, **12:3**, pp. 85–94, September 2005.

Carlson, Jonas, Rasmus Havmöller, Alberto Herreros, Pyotr G. Platonov, Rolf Johansson, and S. B. Olsson: "Can orthogonal lead indicators of propensity for atrial fibrillation be accurately assessed from the 12-lead ECG?" *Europace*, **7**, pp. S39–S48, 2005.

de Maré, Lena, Stéphane Velut, Erika Ledung, Christian Cimander, Bo Norrman, Eva Nordberg Karlsson, Olle Holst, and Per Hagander: "A cultivation technique for *E. coli* fed-batch cultivations operating close to the maximum oxygen transfer capacity of the reactor." *Biotechnology Letters*, **27:14**, pp. 983–990, July 2005.

Gäfvert, Magnus, and Jacob Svendenius: "A novel semi-empirical tire model for combined braking and cornering." *Vehicle System Dynamics*, **5:43**, May 2005.

Hägglund, Tore: "Book review: Control systems with input and output constraints, by A.H. Glattfelder and W. Schaufelberger." *Control Engineering Practice*, **13/1**, p. 131, 2005.

Hägglund, Tore: "Industrial implementation of on-line performance monitoring tools." *Control Engineering Practice*, **13**, pp. 1383–1390, 2005.

Ingimundarson, Ari, and Tore Hägglund: "Closed-loop performance monitoring using loop tuning." *Journal of Process Control*, **15:2**, pp. 127–133, 2005.

Karlsson, Magnus, Ola Slätteke, Björn Wittenmark, and Stig Stenström: "Reducing moisture transients in the paper-machine drying section with the mid-ranging control technique." *Nordic Pulp and Paper Research Journal*, **20:2**, pp. 150–156, June 2005.

Prajna, Stephen, and Anders Rantzer: "Convex programs for temporal verification of nonlinear dynamical systems.". Submitted for journal publication, 2005.

Rantzer, Anders: "On relaxed dynamic programming in switching systems.". to appear in special issue on hybrid systems, IEE Proceedings, September 2006, 2005.

Sandberg, Henrik, and Bo Bernhardsson: "A Bode sensitivity integral for linear time-periodic systems." *IEEE Transactions on Automatic Control*, **50:12**, pp. 2034–2039, December 2005.

Sandberg, Henrik, Erik Möllerstedt, and Bo Bernhardsson: "Frequency-domain analysis of linear time-periodic systems." *IEEE Transactions on Automatic Control*, **50:12**, pp. 1971–1983, December 2005.

Strandh, Petter, Johan Bengtsson, Rolf Johansson, Per Tunestål, and Bengt Johansson: "Variable valve actuation for timing control of a homogeneous charge compression ignition engine." *SAE Paper 2005-01-0147*, March, March 2005.

Conference Papers

Åkesson, Johan, and Karl Johan Åström: "Manual control and stabilization of an inverted pendulum." In *Proc. 16th IFAC World Congress*, Prague, Czech Republic, July 2005.

Alriksson, Peter, and Anders Rantzer: "Sub-optimal sensor scheduling with error bounds." In *Proc. 16th IFAC World Congress*, Prague, Czech Republic, July 2005.

Andersson, Martin, Dan Henriksson, Anton Cervin, and Karl-Erik Årzén: "Simulation of wireless networked control systems." In *Proceedings of the 44th IEEE Conference on Decision and Control and European Control Conference ECC 2005*, Seville, Spain, December 2005.

Årzén, Karl-Erik, and Anton Cervin: "Control and embedded computing: Survey of research directions." In *Proc. 16th IFAC World Congress*. Elsevier, July 2005.

Åström, Karl Johan, Javier Aracil, and Francisco Gordillo: "A new family of smooth strategies for swinging up a pendulum." In *Proc. 16th IFAC World Congress*, Prague, Czech Republic, 2005.

Cervin, Anton: "Analysis of overrun strategies in periodic control tasks." In *Proc. 16th IFAC World Congress*, Prague, Czech Republic, July 2005.

Gattami, Ather, and Johannes Berglund: "Stabilization of vehicle formations—A case study." In *Proceedings of the 3rd Swedish Workshop on Autonomous Robotics, Stockholm, Sweden*, September 2005.

Gattami, Ather, and Anders Rantzer: "Linear quadratic performance criteria for cascade control." In *Proceedings of the 44th IEEE Conference on Decision and Control and European Control Conference, Seville, Spain*, December 2005.

Gámez García, Javier, Anders Robertsson, Juan Gómez Ortega, and Rolf Johansson: "Automatic calibration procedure for a robotic manipulator force observer." In *Proc. of the 2005 IEEE Int. Conf. on Robotics and Automation (ICRA'05)*, Barcelona, Spain, April 2005.

Gámez García, Javier, Anders Robertsson, Juan Gómez Ortega, and Rolf Johansson: "Calibración automática de un observador de la fuerza de contacto para un robot manipulador." In *XXVI Jornadas de Automática*, Alicante, Spain, September 2005.

Gámez García, Javier, Anders Robertsson, Juan Gómez Ortega, and Rolf Johansson: "Force and acceleration sensor fusion for compliant robot

motion control." In *Proc. of the 2005 IEEE Int. Conf. on Robotics and Automation (ICRA'05)*, Barcelona, Spain, April 2005.

Gámez García, Javier, Anders Robertsson, Juan Gómez Ortega, and Rolf Johansson: "Self calibrating procedure for a 3D force observer." In *Proc. 44th IEEE Conference on Decision and Control, and the European Control Conference 2005*, Seville, Spain, December 2005.

Haugwitz, Staffan, and Per Hagander: "Process control of an Open Plate Reactor." In *Proceedings of the 16th IFAC World Congress*, Prague, Czech Republic, July 2005.

Haugwitz, Staffan, Maria Karlsson, Stéphane Velut, and Per Hagander: "Anti-windup in mid-ranging control." In *Proceedings of the 44th IEEE Conference on Decision and Control and European Control Conference ECC 2005*, Seville, Spain, December 2005.

Henriksson, Dan, and Anton Cervin: "Optimal on-line sampling period assignment for real-time control tasks based on plant state information." In *Proceedings of the 44th IEEE Conference on Decision and Control and European Control Conference ECC 2005*, Seville, Spain, December 2005.

Kao, Chung-Yao, and Anders Rantzer: "Robust stability analysis of linear systems with time-varying delays." In *Proceedings of 16th IFAC World Congress*, Prague, Czech Republic, July 2005.

Musulin, Estanislao, María J. Arbiza, Anna Bonfill, Luis Puigjaner, Rasmus Olsson, and Karl-Erik Årzén: "Closing the information loop in recipe-based batch production." In *Proceedings of European Symposium on Computer Aided Process Engineering—ESCAPE 15*, May 2005.

Nilsson, Klas, Rolf Johansson, Anders Robertsson, Rainer Bischoff, Torgny Brogårdh, and Martin Hägele: "Productive robots and the SMErobot project." In *Final Program and Book of Abstracts of Third Swedish Workshop on Autonomous Robotics*, Stockholm, September 2005. FOI, Swedish Defence Research Agency.

Nilsson, Robert, and Dan Henriksson: "Test case generation for flexible real-time control systems." In *Proceedings of the 10th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA05)*, Catania, Sicily, Italy, September 2005.

Nordfeldt, Pontus, and Tore Hägglund: "Design of PID controllers for decoupled multi-variable systems." In *Proc. 16th IFAC World Congress*, Prague, Czech Republic, July 2005.

Olsson, Tomas, Rolf Johansson, and Anders Robertsson: "Force/vision based active damping control of contact transition in dynamic environments." In *Proc. 10th IEEE Int. Conf. Computer Vision, Workshop on Dynamical Vision*, Beijing, October 2005.

Otter, Martin, Karl-Erik Årzén, and Isolde Dressler: "Stategraph—A Modelica library for hierarchical state machines." In *Modelica 2005 Proceedings*, 2005.

Prajna, Stephen, and Anders Rantzer: "On the necessity of barrier certificates." In *Proceedings of the IFAC World Congress*, Prague, Czech Republic, July 2005.

Prajna, Stephen, and Henrik Sandberg: "On model reduction of polynomial dynamical systems." In *Proceedings of the 44th IEEE Conference on Decision and Control and European Control Conference ECC 2005*, Seville, Spain, December 2005.

Purvis, K.B., Karl Johan Åström, and M. H. Khammash: "Estimating radar positions using unmanned air vehicle teams engaged in cooperative deception." In *Proc. 2005 American Control Conference*, Poartland, Oregon, USA, 2005.

Rantzer, Anders: "On approximate dynamic programming in switching systems." In *Proceedings of 44th Conference on Decision and Control and European Control Conference 2005*, Seville, December 2005.

Shiriaev, Anton, Rolf Johansson, Anders Robertsson, and Leonid Freidovich: "Output feedback stabilization of the Moore-Greitzer compressor model." In *Proc. 44th IEEE Conference on Decision and Control, and the European Control Conference 2005,*, pp. 1102–1107, Seville, Spain, December 12-15, 2005, December 2005.

Shiriaev, Anton, Anders Robertsson, and Leonid Freidovich: "Motion planning and dynamical positioning for a fleet of underactuated ships." In *Book of Abstracts of Third Swedish Workshop on Autonomous Robotics*, FOI 2005, Stockholm, September 2005.

Shiriaev, Anton, Anders Robertsson, Paul Pacull, and Thor I. Fossen: "Motion planning and its feedback stabilization for underactuated ships: Virtual constraints approach." In *Proc. 16th IFAC World Congress*, Prague, Czech Republic, July 2005.

Shiriaev, Anton, Anders Robertsson, John Perram, and Anders Sandberg: "Periodic motion planning for virtually constrained (hybrid) mechanical systems." In *Proc. 44th IEEE Conference on Decision and Control,*

and the European Control Conference 2005, pp. 4035–4040, Seville, Spain, December 2005.

Slätteke, Ola, and Karl Johan Åström: "Modeling of a steam heated rotating cylinder—A grey-box approach." In *Proc. 2005 American Control Conference*, Portland, Oregon, USA, June 2005.

Wernrud, Andreas, and Anders Rantzer: "On approximate policy iteration for continuous-time systems." In *Proceedings of the 44th IEEE Conference on Decision and Control and European Control Conference*, Seville, Spain, December 2005.

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Reports

During this year 2 PhD theses and 3 Licentiate theses have been published. The abstracts are presented in Chapter 7. Also 27 Master theses and 4 internal reports have been completed.

Dissertations

Haugwitz, Staffan: "Modeling and Control of the Open Plate Reactor." Licentiate Thesis ISRN LUTFD2/TFRT--3237--SE, Department of Automatic Control, Lund University, Sweden, September 2005.

Kjær, Martin Ansbjerg: "Active stabilization of thermoacoustic oscillation." Licentiate Thesis ISRN LUTFD2/TFRT--3239--SE, Department of Automatic Control, Lund University, Sweden, December 2005.

Nordfeldt, Pontus: "PID control of TITO systems." Licentiate Thesis ISRN LUTFD2/TFRT--3238--SE, Department of Automatic Control, Lund University, Sweden, December 2005.

Olsson, Rasmus: *Batch Control and Diagnosis*. PhD thesis ISRN LUTFD2/TFRT--1073--SE, Department of Automatic Control, Lund University, Sweden, June 2005.

Velut, Stéphane: *Probing Control. Analysis and Design with Application to Fed-Batch Bioreactors*. PhD thesis ISRN LUTFD2/TFRT--1072--SE, Department of Automatic Control, Lund University, Sweden, June 2005.

Master's Theses

Almbladh, Per: "Experimental study of adaptation and postural control

after sleep deprivation." Master Thesis ISRN LUTFD2/TFRT--5755--SE, Department of Automatic Control, Lund University, Sweden, August 2005.

Berglund, Johannes: "Stabilization of vehicle formations—A case study." Master Thesis ISRN LUTFD2/TFRT--5751--SE, Department of Automatic Control, Lund University, Sweden, June 2005.

Bjöörn, Fredrik, and Olof Garpinger: "Modeling and control of a large deformable mirror." Master Thesis ISRN LUTFD2/TFRT--5742--SE, Department of Automatic Control, Lund University, Sweden, April 2005.

Bracci, Marco: "Greybox identification and control design with Dymola." Master Thesis ISRN LUTFD2/TFRT--5757--SE, Department of Automatic Control, Lund University, Sweden, September 2005.

Carlas Ponce, Ferran: "Portable robot control." Master Thesis ISRN LUTFD2/TFRT--5756--SE, Department of Automatic Control, Lund University, Sweden, June 2005.

Chong, Chin Yuan: "Cooperative robots." Master Thesis ISRN LUTFD2/TFRT--5741--SE, Department of Automatic Control, Lund University, Sweden, January 2005.

Enckell, Carl, and Mikael Pehrsson: "A model for MES in pharmaceutical production—An AstraZeneca case study." Master Thesis ISRN LUTFD2/TFRT--5761--SE, Department of Automatic Control, Lund University, Sweden, December 2005.

Göransson, Marie, and Erik Johannesson: "Integrated stereovision for an autonomous ground vehicle competing in the Darpa Grand Challenge." Master Thesis ISRN LUTFD2/TFRT--5760--SE, Department of Automatic Control, Lund University, Sweden, December 2005.

Graf, Jens: "Teleoperation and autonomous navigation of a mobile robot using wireless vision feedback." Master Thesis ISRN LUTFD2/TFRT--5740--SE, Department of Automatic Control, Lund University, Sweden, March 2005.

Gustafsson, Matilda, and Emma Jönsson: "Easysee—A tool for visualization of data obtained during climate testing," (Swedish). Master Thesis, Department of Automatic Control, Lund University, Sweden, June 2005.

Henningsson, Toivo: "Logarithmic concave observers." Master Thesis ISRN LUTFD2/TFRT--5747--SE, Department of Automatic Control, Lund University, Sweden, May 2005.

Holmqvist, Johan, and Adrian Ulander: “Hardware simulation for testing IEC 61131-3.” Master Thesis ISRN LUTFD2/TFRT--5739--SE, Department of Automatic Control, Lund University, Sweden, January 2005.

Hörberg, Arne: “ABS på radiostyrd bil (ABS for a radiocontrolled car).” Master Thesis ISRN LUTFD2/TFRT--5743--SE, Department of Automatic Control, Lund University, Sweden, May 2005.

Jägerhök, Jonas: “Model-based grade change support.” Master Thesis ISRN LUTFD2/TFRT--5754--SE, Department of Automatic Control, Lund University, Sweden, January 2005.

Johansson, Thomas: “Control of a spider crane.” Master Thesis ISRN LUTFD2/TFRT--5763--SE, Department of Automatic Control, Lund University, Sweden, December 2005.

Karlsson, Johan: “Vision system for quality of the weaving process.” Master Thesis ISRN LUTFD2/TFRT--5753--SE, Department of Automatic Control, Lund University, Sweden, February 2005.

Karlsson, Maria: “Control of bacillus Subtilis culivations—Feeding strategies and the role of anti-windup in mid-ranging control.” Master Thesis ISRN LUTFD2/TFRT--5745--SE, Department of Automatic Control, Lund University, Sweden, May 2005.

Kwapisz, Michael: “Control of an inverted pendulum (Pendubot).” Master Thesis ISRN LUTFD2/TFRT--5735--SE, Department of Automatic Control, Lund University, Sweden, January 2005.

Larsson, Per-Ola: “Modeling and prediction of radio channels for orthogonal frequency division multiplexing.” Master Thesis ISRN LUTFD2/TFRT--5758--SE, Department of Automatic Control, Lund University, Sweden, November 2005.

Llorente, Ana: “Code generation from JGrafchart to ATMEL AVR.” Master Thesis ISRN LUTFD2/TFRT--5749--SE, Department of Automatic Control, Lund University, Sweden, January 2005.

Madjidian, Daria, and Arash Majedi: “Dynamic simulation of the train concept Nowait Transit.” Master Thesis ISRN LUTFD2/TFRT--5748--SE, Department of Automatic Control, Lund University, Sweden, May 2005.

Meerstetter, Marcel: “A spherical pendulum modeling & control.” Master Thesis ISRN LUTFD2/TFRT--5738--SE, Department of Automatic Control, Lund University, Sweden, January 2005.

Nilsson, Lars: "Lifetime monitoring of wind turbines." Master Thesis ISRN LUTFD2/TFRT--5759--SE, Department of Automatic Control, Lund University, Sweden, November 2005.

Nyström, Lisa: "Online terrain classification for Team CalTech in DARPA Grand Challenge." Master Thesis ISRN LUTFD2/TFRT--5762--SE, Department of Automatic Control, Lund University, Sweden, November 2005.

Palm, Ola: "Vehicle dynamics control for rollover mitigation." Master Thesis ISRN LUTFD2/TFRT--5746--SE, Department of Automatic Control, Lund University, Sweden, May 2005.

Sandberg, Olof: "Controlling the secondary mirror cell of the Euro50 project using an interial measurement unit." Master Thesis ISRN LUTFD2/TFRT--5750--SE, Department of Automatic Control, Lund University, Sweden, May 2005.

Slättorp, Karl, and Kristian Tuszynski: "Model of hydro power plan—New algorithm for turbine governors." Master Thesis ISRN LUTFD2/TFRT--5744--SE, Department of Automatic Control, Lund University, Sweden, May 2005.

Other Reports

Andersson, Martin, Dan Henriksson, and Anton Cervin: *TrueTime 1.3—Reference Manual*, June 2005.

Haugwitz, Staffan: "Plattreaktorn öppnar nya vägar för kemiindustrin." March 2005. Populärvetenskaplig artikel i samband med kursen Kommunikationsteknik HT2004.

Henriksson, Dan, Ola Redell, Jad El-Khoury, Martin Törngren, and Karl-Erik Årzén: "Tools for real-time control systems co-design—A survey." Technical Report ISRN LUTFD2/TFRT--7612--SE, Department of Automatic Control, Lund Institute of Technology, Sweden, April 2005.

Tuszynski, Agneta, and Per Hagander: "Automatic control 2004. activity report." Technical Report ISRN LUTFD2/TFRT--4032--SE, Department of Automatic Control, Lund Institute of Technology, Sweden, June 2005.

Reports Available

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

- Linköpings Universitetsbibliotek, Svensktrycket,
  SE-581 83 Linköping
- UB, Svenska Tryckavdelningen, Box 1010, SE-221 03 Lund
- Stockholms Universitetsbibliotek, Svenska Tryckavdelningen,
  SE-106 91 Stockholm
- Kungliga Biblioteket, Box 5039, SE-102 41 Stockholm
- Umeå Universitetsbibliotek, Box 718, SE-901 10 Umeå
- Uppsala Universitetsbibliotek, Box 510, SE-751 20 Uppsala

Almost all our publications are available in full through our web server http://www.control.lth.se/publications.

The reports in the 1000- and 3000-series may be ordered from the Department, see address on page 4. Please be certain to specify both the report number and report title.

There is a copying and handling charge of between 300 and 500 SEK for each document. Invoice will be sent together with the ordered report(s).

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Lectures by the Staff Outside the Department

Årzén, Karl-Erik

Networked Embedded Control, RUNES Meeting, RWTH AAchen, Germany, February 1.

Integrated Control Design and Implementation; Control of Computing Systems; Jitterbug and TrueTime, ARTIST2 Graduate Course on Embedded Control Systems, Valencia, Spain, April 6-7.

Control and Real-Time Computing Research in Lund, Linköping University, Sweden, May 26.

TrueTime: Real-Time Control System Simulation Using Matlab/Simulink, Pre-congress tutorial at the 16th IFAC World Congress, Prague, Czech Republic, July 3.

The ARTIST2 roadmap on real-time control, RTC2005, Palma Mallorca, July 5.

A survey of co-design tools for control, computing and communication, RTC2005, Palma Mallorca, July 5.

Control and Embedded Computing: Survey of Research Directions, IFAC World Congress 2005, Prague, July 8.

Timing Analysis and Simulation Tools for Real-Time Control, Plenary address, Formal Modeling and Analysis of Timed Systems (FORMATS'05), Uppsala, Sweden, September 17.

Åström, Karl Johan

A Family of Smooth Strategies for Swinging up an Inverted Pendulum, Center for Control and Computation. University of California Santa Barbara, Santa Barbara, CA, USA, January 21.

Event based control, Symposium in the Honor of Pravin Variay, Berkeley, CA, USA, June 21.

Control the Hidden Technology, Peter Sagirow Distinguished Seminar, University of Stuttgardt, Germany, June 21.

A new family of smooth strategies for swinging up a pendulum, The 16th IFAC World Congress, Prague, Czech Republic, July 8.

Manual control and stabilization of an inverted pendulum, The 16th IFAC World Congress, Prague, Chech Republic, July 8.

Control Design – A Perspective. NI Week, National Instruments Austin TX, USA, August 16.

Safe manual control of unstable systems, ATTACS'05, Tokyo, Japan, October 1.

Modeling of Physical System, TDU Tokyo, Japan, October 4.

The bicycle as a human mechatronic device, Joint COE/HAN Workshop, Tokyo, Japan, October 6.

Bicycle Dynamics and Control, Tokyo Institute of Technology, Tokyo, October 11.

Differential Algebrai Equations, TDU Tokyo, Japan, October 14.

Physics-based model reduction of nonlinear high-dimensional systems—A Case Study, Toyota Research Lab, Tokyo, Japan, October 17.

Bicycle Modeling and Control, TDU Tokyo, Japan, October 18.

Friction Modeling and Friction Compensation, TDU Tokyo, Japan, October 20.

Even Based Control COE/HAM Symposium, Tokyo, Japan, October 26.

Steam Generator Modeling, TDU Tokyo, Japan, October 28.

Nyquist and his seminal paper, The inaugural ASME Nyquist Lecture. Orlando Florida, USA, November 8.

Ingenjörsutbildning och cykling, Sven Spanne Symposium. Department of Mathematics, Lund University, Lund, Sweden, December 7.

Cervin, Anton

Integrated Control Design and Implementation; Control of Computing Systems; Jitterbug and TrueTime, ARTIST2 Graduate Course on Embedded Control Systems, Valencia, Spain, April 6–7.

TrueTime: Real-Time Control System Simulation Using Matlab/Simulink, Pre-congress tutorial at the 16th IFAC World Congress, Prague, Czech Republic, July 3.

Analysis of Overrun Strategies in Periodic Control Tasks, 16th IFAC World Congress, Prague, Czech Republic, July 8.

Control Task Timing and Quality of Control (QoC), ETR'05 Summer School on Real-Time Systems, Nancy, France, September 16.

Hägglund, Tore

Process Control in Practice, Industrial course. Stockholm, Sweden, March 8–9.

Process Control in Practice, Industrial course. Stockholm, Sweden, May 18–19.

Decentralized Approaches to Process Control, PhD Course. Dep. Informática y Automática, ETSI Informática, Madrid, Spain, October 17–21.

Process Control in Practice, Industrial course. Stockholm, Sweden, November 29–30.

Haugwitz, Staffan

Process control of an Open Plate Reactor, IFAC World Congress, Prague, July, 4-8.

Anti-windup in Mid-ranging control, 44th IEEE Conference on Decision and Control and European Control Conference (CDC-ECC '05), Seville, December 12-15.

Henriksson, Dan

TrueTime: Real-Time Control System Simulation Using MATLAB/Simulink, Tutorial given at the 16th IFAC World Congress, Prague, Czech Republic, July 3.

Optimal On-line Sampling Period Assignment for Real-Time Control Tasks Based on Plant State Information, 44th IEEE Conference on Decision and Control and European Control Conference ECC 2005, Seville, Spain, December 14.

Johansson, Rolf

Control of Homogeneous Charge Compression Ignition (HCCI) Combustion Engines, Dipartimento di Elettronica e Informazione, Politecnico di Milano, Milano, Italy, May 2.

Hybrid Control of Homogeneous Charge Compression Ignition (HCCI) Combustion Engines, HYCON Workshop on Automotive Applications of Hybrid Systems, PARADES, Rome, Italy, May 27.

Hybrid Control of Homogeneous Charge Compression Ignition (HCCI) Combustion Engines, University of California, Berkeley, Dept Mechanical Engineering, June 10 (Invited).

Model-Predictive Control of Homogeneous Charge Compression Ignition (HCCI) Combustion Engines, Universidad de Jaén, Jaén, Spain, July 12.

Hybrid Control of Homogeneous Charge Compression Ignition (HCCI) Combustion Engines, Umeå University, Dept. Applied Physics and Electronics, Umeå, Sweden, December 1.

Charlotta Johnsson

ISA95 - Vendor, End-user, Academic and Consultant Perspective, WBF Annual Conference 2005, Atlantic City; NJ, USA, May 15–18.

S95 overview (tutorial), WBF Annual Conference 2005, Atlantic City; NJ, USA, May 15.

Olsson, Tomas

Force/Vision Based Active Damping Control of Contact Transition in Dynamic Environments, IEEE International Conference on Computer Vision, Workshop on Dynamical Vision, Beijing, October 21.

Rantzer, Anders

Density and flow: A different view on nonlinear control, California Institute of Technology, USA, February 15.

Hybrid control using approximate dynamic programming—approaching large problems, Review meeting for the EU project CC—Control and Computation, ETH, Zürich, Switzerland, March 12.

Price mechanisms for distributed estimation and control, Invited lecture, Workshop on Integrated Control, Estimation and Communication, California Institute of Technology, USA, March 31.

On Approximate Dynamic Programming in Nonlinear and Hybrid Control, seminar, University of Minnesota, USA, April 12.

On Approximate Dynamic Programming in Nonlinear and Hybrid Control, Invited seminar, Massachusetts Institute of Technology, USA, April 13.

On convexity and relaxation in nonlinear and hybrid control, Invited seminar, Stanford University, USA, April 28.

On linear quadratic dynamic team theory, Invited seminar, University of California at Santa Barbara, USA, May 26.

On linear quadratic dynamic team theory, California Institute of Technology, USA, June 14.

On scalability in network control, HYCON project meeting, ETH, Zürich, Switzerland, July 12.

Control Synthesis for Roll-over Prevention, CEMACS review meeting, Daimler-Chrysler, Stuttgart, Germany, November 30.

On Approximate Dynamic Programming in Switching Systems, Conference on Decision and Control and European Control Conference 2005, Seville, Spain, December.

Robertsson, Anders

Lectures on Nonlinear Control (lecture I-IV), Umeå University, Umeå, Sweden, January.

Presentation of research activities, Workshop on Future of control and computing systems, organized by T. Abdelzaher, J. Hellerstein, and D. Tilbury, sponsored by the US National Science Foundation (NFS), May.

On Dynamic Output Feedback Stabilization of Nonlinear Systems, Seminar at LASMEA, Université Blaise Pascal, Clermont-Ferrand, France, May 10.

Observers and state reconstruction, lecture at IFMA, Clermont-Ferrand, France, May 11.

ARTIST2-meeting, Workshop on Control for Embedded Systems, Lund, June 13-16.

Control in Communication and Queueing Systems, (Swe. "Reglerteknik i kommunikations- och kösystem") Public lecture ("docentföreläsning") Lund, Sweden, June 16.

Productive robots and the SMErobot project, presentation at the Third Swedish Workshop on Autonomous Robotics, FOI, Stockholm, Sweden, September 2.

Force and compliance control for industrial robot applications, workshop on compliant motion and robot control, DLR, Germany, November 10.

Sandberg, Henrik

Frequency-Domain Analysis of Linear Time-Periodic Systems, Invited lecture. Optimization and Systems Theory, KTH, Stockholm, Sweden, May 20.

Frequency-Domain Analysis of Linear Time-Periodic Systems, Invited lecture. Research School of Information Sciences and Engineering, the Australian National University, Canberra, Australia, July 29.

Frequency-Domain Analysis of Linear Time-Periodic Systems, Invited lecture. Department of Electrical and Electronic Engineering, the University of Melbourne, Australia, August 5.

Slätteke, Ola

Control of the Drying Section of a Paper Machine, Invited lecture by Honeywell, Vancouver, Canada, May 17.

Modeling of a Steam Heated Rotating Cylinder - A Grey Box Approach, American Control Conference (ACC'05), Portland, OR, USA, June 8.

Wittenmark, Björn

Admission control in web-server systems, Invited lecture, University of Newcastle, Australia, April 20. *Admission control in web-server systems,*, Invited lecture, California Institute of Technology, USA, October 27.

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Seminars at the Department

Seminars presented in order of date. The seminars were given at the department during 2005, both by the staff and by invited lecturers. Dissertations and master's theses presentations are also included.

AC = Department of Automatic Control, Lund Institute of Technology
LTH = Lund Institute of Technology

Feb 24: **Karl Hedrick**(UC Berkeley), *Control of Multiple, Collaborating Unmanned Vehicles.*

Mar 9: **Adrian Ulander, Johan Holmqvist** (LTH), *Hardware simulation for testing IEC 61131-3.* MSc-thesis presentation.

Mar 10: **Karl Slättorp, Kristian Tuszynski** (LTH), *Model of Hydro Power Plant—New Algorithm for Turbine Governers.* MSc-thesis presentation.

Mar 17: **Anton Shiriaev** (Umeå University), *Output Feedback Stabilization of the Moore-Greitzer Compressor Model.*

Mar 18: **Jens Graf** (TU Darmstadt), *Teleoperation and Autonomous Navigation of a Mobile Robot Using Wireless Vision Feedback.* MSc-thesis presentation.

Mar 18: **Olof Sandberg** (LTH), *Control of the Euro 50 Secondary Mirrorcell.* MSc-thesis presentation.

Mar 18: **Olof Garpinger, Fredrik Bjöörn** (LTH), *Modeling and Control of a Deformable Telescope Mirror.* MSc-thesis presentation.

Mar 18: **Roger Svahn** (LTH), *Actuator servos for deformable mirrors.* (LTH) MSc-thesis presentation.

Mar 29: **Ola Palm** (LTH), *Vehicle Dynamics Control for Rollover Mitigation.* MSc-thesis presentation.

Mar 30: **Chin Yuan Chong** (LTH), *Cooperative Robots.* MSc-thesis presentation.

Apr 12: **Arne Hörberg** (LTH), *ABS på radiostyrd bil.* MSc-thesis presentation.

Apr 15: **Thomas Svantesson** (Saab Bofors Dynamics), *Missile Guidance & Control.*

Apr 26: **Sebastian Dormido** (UNED Madrid), *Ejs:A freeware, open source tool to create web-based virtual and remote labs.*

Apr 28: **Sebastian Dormido** (UNED Madrid), *SysQuake: A highly interactive Matlab-like environment.*

May 9: **Maria Karlsson** (LTH), *Control of Bacillus subtilis Cultivations - Feeding Strategies and the Role of Anti-windup in Mid-ranging Control.* MSc-thesis presentation.

May 10: **Toivo Henningsson** (LTH), *Logarithmic Concave Observers.* MSc-thesis presentation.

May 17: **Arash Majedi, Daria Madjidian** (LTH), *Dynamic Simulation of the Nowait Transit Train Concept.* MSc-thesis presentation.

May 19: **Jonas Jägerhök** (LTH), *Model Based Grade Change Support.* MSc-thesis presentation.

May 24: **Marco Bracci** (Università degli studi di Firenze), *Grey Box Identification Using Dymola.* MSc-thesis presentation.

May 27: **Jon Gunther** (UCSB), *Process Monitoring and Diagnosis Opportunities in Fed-Batch Fermentation.* MSc-thesis presentation.

June 2: **Johannes Berglund** (LTH), *Stabilization of Vehicle Formations—A Case Study.* MSc-thesis presentation.

June 3: **Frank Allgöwer** (University of Stuttgart), *Nonlinear Model Predictive Control: From Theory to Applications.*

June 3: **Stéphane Velut** (AC), *Probing Control. Analysis and Design with Application to Fed-Batch Bioreactors.* Doctoral dissertation defence.

June 16: **Anders Robertsson** (AC), *Reglerteknik i kommunikations- och kösystem.* Docent lecture.

June 16: **Ferran Carlas, Juan Periset** (Universitat Politecnica de Catalunya and Universidad de Zaragoza), *Portable Robot Programming and Control.* MSc-thesis presentation.

June 17: **Rasmus Olsson** (AC), *Batch Control and Diagnosis.* Doctoral dissertation defence.

June 21: **Emma Jönsson, Matilda Gustafsson** (LTH), *EasySee - Ett verktyg för visualisering av mätdata från klimatprovning.* MSc-thesis presentation.

June 22: **Per Almbladh** (LTH), *Experimental Study of Adaptation and Postural Control after Sleep Deprivation.* MSc-thesis presentation.

June 23: **Michael Rotkowitz** (Stanford University), *Tractable Problems in Optimal Decentralized Control.*

June 30: **Yasamin Mostofi** (California Institute of Technology), *Integration of Communication and Control for Delay-sensitive Wireless Applications.*

June 30: **Michal Kutil** (Czech Technical University in Prague), *Traffic Intersection Control.*

June 30: **Manuel Lluesma** (Polytechnic University of Valencia), *Jitter vs Fixed Delay.*

Sep 2: **Staffan Haugwitz** (AC), *Modeling and Control of the Open Plate Reactor.* Lic Tech dissertation seminar.

Sep 2: **Krister Forsman** (Perstorp Specialty Chemicals AB), *Kemiindustriautomationsutmaningar.*

Sep 8: **Rick Middleton** (University of Newcastle), *On the Relationship Between Input Constrained Model Predictive Control and Anti-Windup Control.*

Sep 13: **José Luis Guzmán Sánchez** (University of Almería), *Interactive Tools and a Robust GPC-QFT Approach.*

Sep 15: **Jonathan Chauvin** (Ecole des Mines de Paris), *Advanced Control of HCCI Engine.*

Sep 22: **Zdenek Hanzalek** (Czech Technical University), *Scheduling of Algorithm and Tasks on FPGAs.*

Sep 27: **Lars Grüne** (Universität Bayreuth), *Set Oriented and Graph Theoretic Methods for Optimal Feedback Stabilization.*

Sep 30: **Martin Nilsson** (Swedish Institute of Computer Science), *Tre år med Datamekatronik—hur har det gått, och vad kan man dra för slutsatser?.*

Oct 10: **John C. Doyle** (California Institute of Technology), *Network Complexity and Robustness.*

Oct 28: **Per-Ola Larsson** (LTH), *Modeling and prediction of radio channels for OFDM.* MSc-thesis presentation.

Nov 17: **Leonid Freidovich** (Umeå University), *Lyapunov-Based Switching Control of Nonlinear Systems Using High-Gain Observers.*

Nov 22: **Lars Nilsson** (LTH), *Lifetime Monitoring of Wind Turbines.*

Nov 24: **Michel Verhaegen** (Delft University), *Spatial Canonical Approach to Multidimensional State-Space identification for Distributed Parameter Systems.*

Nov 29: **Lisa Nyström** (LTH), *Online terrain classification for Team Caltech in DARPA Grand Challenge.* MSc-thesis presentation.

Nov 29: **Erik Johannesson, Marie Göransson** (LTH), *Integrated Stereovision for an Autonomous Ground Vehicle Competing in the DARPA Grand Challenge.* MSc-thesis presentation.

Dec 2: **Carl Enckell, Mikael Pehrsson** (LTH), *A Model for MES in Pharmaceutical Production—An AstraZeneca Case Study.* MSc-thesis presentation.

Dec 6: **Rosa Castane** (UPC, Barcelona), *Feedback Scheduling Assuming Non-Stationary Noise Processes.*

Dec 16: **Pontus Nordfeldt** (AC), *PID Control of TITO Systems.* Lic Tech dissertation seminar.

Dec 20: **Martin Ansbjerg Kjær** (AC), *Active Stabilization of Thermoacoustic Oscillation.* Lic Tech dissertation seminar.

Dec 20: **Jan Tommy Gravdahl** (NTNU, Trondheim, Norway), *Surge in Centrifugal Compressors: Modeling and Active Control.*

Dec 22: **Thomas Johansson** (LTH), *Control of a Spider Crane.* MSc-thesis presentation.

Dec 22: **Camran Razavi** (LTH), *Error Detection in the Active Front Steering System.* MSc-thesis presentation.