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Activity Report

Automatic Control 2007

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1

Introduction

This report covers the activities at the Department of Automatic Control, at Lund University from January 1 to December 31, 2007. The budget for 2007 was 27.5 MSEK. The proportion coming from the university was 54%.

Five PhD theses were defended this year, by Jacob Svendenius, Tomas Olsson, Ather Gattami, Staffan Haugwitz, and Johan Åkesson. This brings the total number of PhDs graduating from our department to 81. Mikael Lindberg has been admitted as PhD student during the year. Three persons with doctor's degree left the department: Jacob Svendenius, Tomas Olsson, and Staffan Haugwitz. Jacob Svendenius works for Haldex Brake Products AB in Landskrona, Tomas Olsson started to work for ABB Robotics in Västerås and Staffan Hugwitz works now for Borealis in Stenungsund. Martin Ohlin also left our department during the year.

In the civilingenjör (engineering) program we have 11 courses. The total number of students who finished the courses were 790, and 28 students completed their master theses. The total teaching effort corresponds to 111 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.

	03	04	05	06	07	Sum
Books	4	0	1	1	1	7
Papers	13	17	15	17	19	81
Conference papers	31	39	27	53	31	181
PhD theses	5	3	2	3	5	18
Licentiate theses	4	2	3	3	0	12
Master theses	19	17	27	20	22	105
Internal reports	2	7	2	3	6	20

Acknowledgements

We want to thank our main sponsors: ABB, CECOST, EU Commission, Swedish Energy Agency (STEM), Swedish Foundation for Strategic Research (SSF), The Swedish Agency for Innovation Systems (VINNOVA), The Swedish Research Council (VR), and Toyota Motor Corporation.

2

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:

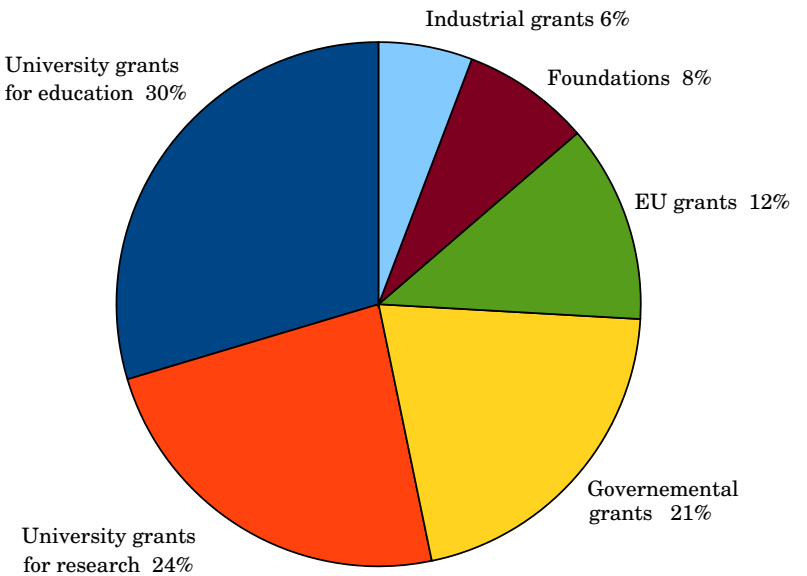
```
control@control.lth.se
```

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

3

Economy and Facilities

The turnover for 2007 was 27,5 MSEK. The income comes from Lund University (54%) and from external grants; the distribution is shown below.



Funding

Lund University provides most of the support for graduate students and also our research is externally funded from governmental agencies and industry. During 2007 we had the following contracts:

- VR – Control of Complex and Nonlinear Systems (block grant)
- VR – Active Control of Compressor Systems Based on New Methods of Nonlinear Dynamic Feedback Stabilization
- VR – Modelling and Control of Server Systems
- VR – Decentralized Structures for Industrial Control II
- VR – Periodic and Event-based Control over Networks
- VINNOVA – Diesel-HCCI in Multi-Cylinder Engines, together with Volvo Powertrain Corporation
- VINNOVA-Ericsson – Feedback Based Resource Management and Code Generation for Soft Real-Time Systems
- SSF – Center for Chemical Process Design and Control (CPDC)
- SSF – Decentralized Control of Complex Systems, Senior Individual Grant, SIG Anders Rantzer
- EU IST-004536 – Reconfigurable Ubiquitous Networked Embedded Systems (RUNES)
- EU IST-004175 – Complex Embedded Automotive Control Systems (CEmACS)
- EU IST-004527 – Embedded Systems Design (ARTIST2)
- EU IST-511368 HYbridCONtrol – Taming Heterogeneity and Complexity of Networked Embedded Systems (HYCON)
- EU IST-507728 EURON II NoE
- 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)
- Haldex Brake Products AB – PhD Research Projects
- Toyota Motor Corporation - Project on Nonlinear Model Reduction
- Swedish Energy Agency (STEM) – Active Control of Combustion Oscillations in Gas Turbines (CECOST)
- Swedish Energy Agency (STEM)– Competence Centre Combustion Processes, KCFP
- STINT - Support visit to Korea
- Royal Physiographic Society – Scholarship
- Knut and Alice Wallenberg – Scholarship
- Hakon Hansson – Scholarship

- Royal Academy of Sciences – Scholarship
- Foundation of Per Westling – Scholarship
- Foundation of Sigfrid and Wahlborg Nordkvist – Scholarship
- Sweden Japan Foundation – Scholarship

The block grant from VR and the CPDC grant from SSF and 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 800 students in total in all our courses per year, and on the average they spend about 15 hours each in the lab.

4

Education

Engineering Program

The engineering education follows the central European systems with a 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 2007, 790 students passed our courses and 28 students completed their master's thesis projects. The number of registered students corresponded to 111 full-year equivalents during the year. The numbers for 2006 were 863, 20, and 128 respectively.

Topics for the master theses were in the following areas: Adaptive control (1), Modeling and simulation (5), Real-time systems (8), Process Automation (2), Robotics and automotive systems (5). A list of the master theses is given in Chapter 12.

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, documentation, manuals, old exams, etc.

Table 4.1 Courses and the number of students who passed.

Reglerteknik AK(FEDIMCPi) *FRT010* (Automatic Control, basic course)	442
Processreglering (KB) *FRT081* (Automatic Process Control)	16
Systemteknik (WN) *FRT110* (Systems Engineering)	85
Digital Reglering *FRT020* (Computer-Controlled Systems)	47
Realtidssystem *FRT031* and FRTN01 (Real-Time Systems)	50+20
Systemidentifiering *FRT041* (System Identification)	10
Prediktiv reglering *FRTN15* (Predictive Control)	23
Olinjär reglering och Servosystem *FRT075* (Nonlinear Control and Servo Systems)	21
Projekt i reglerteknik *FRT090* (Project in Automatic Control)	16
Reglerteori *FRT130* (Control Theory)	10
Matematisk modellering, FK *FRT095* (Mathematical Modelling, Advanced Course)	50
Examensarbete 30 poäng *FRT820* (Master thesis project, 5 months)	28

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/`.

Doctorate Program

Five PhD theses were defended this year, by Jacob Svendenius, Tomas Olsson, Ather Gattami, Staffan Haugwitz, and Johan Åkesson. This brings the total number of PhDs graduating from our department to 81. Abstracts of the theses are given in Chapter 7.

We have admitted Mikael Lindberg as new PhD student during the year.

The following PhD courses were given:

- Structure and Interpretation of Computer Programs (Karl-Erik Årzén) 6 points (9hp)

- Robust Control (Bo Bernhardsson) 6 points (9hp)
- Optimization-Based Methods and Tools in Control (Maciejowski, Haugwitz, Åkesson, Rantzer) 4 points (6hp)
- Linear Systems (Bo Bernhardsson) 5 points (7.5hp)

5

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

Theory and computer tools are developed to deal with fundamental complexity issues appearing in for example vehicles, power systems and communications.

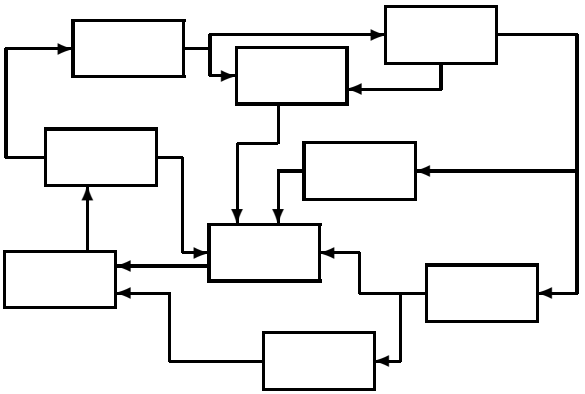


Figure 5.1 A distributed control system.

Distributed Control of Complex Systems

Researchers: Peter Alriksson, Ather Gattami, Toivo Henningsson Perby, Erik Johannesson, 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?

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, Andreas Wernrud, Toivo Henningsson Perby, Anders Rantzer

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 and has found many important applications since then. The idea is general and very simple, but the "curse of dimensionality" is often 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.

Figure 5.2 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.

Modeling and Validation of Complex Systems

Researchers: Oskar Nilsson, Aivar Sootla, Giorgos Kotsalis, Karl Johan Åström, Anders Rantzer

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 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.

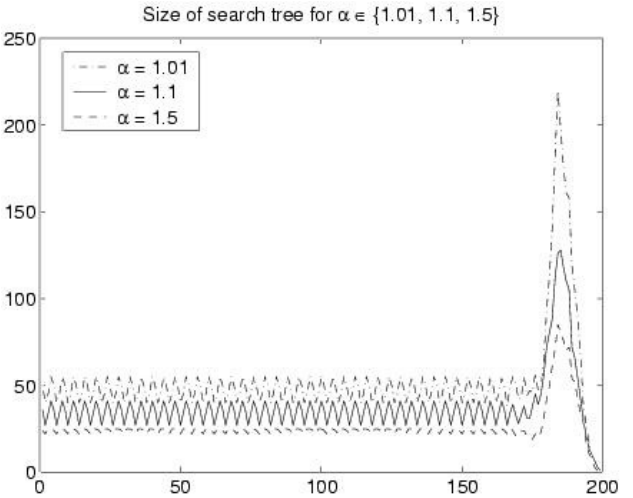


Figure 5.2 The figure illustrates an example where the cost to go is computed backwards in time, starting at T=200. The three parameter values 1.01, 1.1 and 1.5 correspond to accuracies of 1%, 10% and 50% respectively. Notice that the size of the search tree first grows exponentially for time steps down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

One research approach is based on the method of balanced truncation and its extension to nonlinear and hybrid systems. Analysis is done based on linearization around simulated trajectories. Other approaches are based on semi-definite programming and frequency domain sampling. Special attention is given to component-wise reduction for models with block structure. Engine models from Toyota Motor Corporation are used as test cases.

Language Support for Dynamic Optimization

Researchers: Johan Åkesson and Karl-Erik Årzén

Overview Efficient development and operation of control systems is essential in industry today. Optimization is increasingly used as a standard tool to improve operation, both in on-line and off-line applications. Examples are calculation of operating points, grade change trajectories and production schedules that maximize production while minimizing raw material, energy and other resources. Similar issues arise in the design of

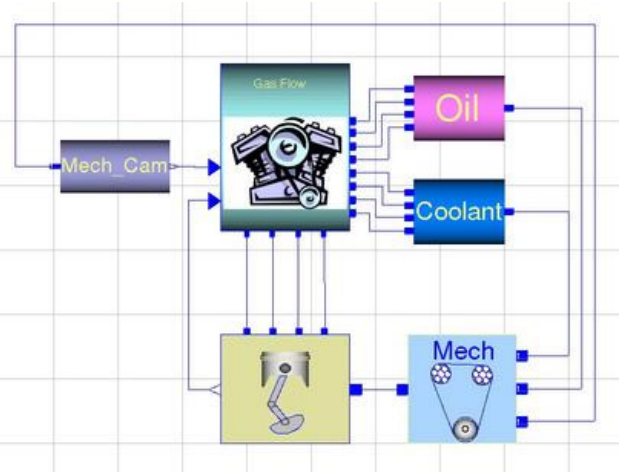


Figure 5.3 Schematic picture of an engine model

embedded control systems for e.g., the automotive, avionics, and mobile telecom areas, where efficient utilization of computing, communication, and/or battery resources is required in order to meet market demands. This can also often be formulated as optimization problems.

Due to the ever increasing complexity of plants, a model-driven approach is required. At the heart of this proposal is a language-based approach for developing a high-level description framework targeted at unified modeling of physical systems and associated optimization problems. This also includes development of prototype software, which transforms a high-level description into a canonical mathematical model representation. This canonical representation may then be used as a basis for code generation for the above mentioned applications. The main topic of the project is the formulation of large-scale optimization problems. Associated with this topic is also code generation for numerical solvers.

Optimica A key issue is the definition of syntax and semantics of the Modelica extension, Optimica. Optimica should provide the user with language constructs that enables formulation of a wide range of optimization problems, such as parameter estimation, optimal control and state estimation based on Modelica models.

At the core of Optimica are the basic optimization elements such as cost functions and constraints. It is also possible to specify bounds on variables

in the Modelica model as well as to mark variables and parameters as optimization quantities, i.e., to express what to optimize over. While this type of information represents a canonical optimization formulation, the user is often required to supply additional information, related to the numerical method which is used to solve the problem. In this category we have e.g., specification of transcription method, discretization of control variables and initial guesses. Optimica should also enable convenient specification of these quantities.

Software Tools – the JModelica compiler In order to demonstrate the proposed concept, prototype software tools, referred to as JModelica, are being developed. In essence, the task of the software is to read the Modelica and Optimica source code and then translate, automatically, the model and optimization descriptions into a format which can be used by a numerical algorithm. The JModelica compiler is developed using the Java-based compiler construction tool JastAdd .

Currently, the front-end of the JModelica compiler supports a subset of Modelica and a basic version of Optimica. In addition, a code-generation back-end for AMPL has been developed. AMPL is a language intended for formulation of algebraic optimization problems. Accordingly, the compiler performs automatic transcription of the original continuous-time problem into an algebraic formulation which can be encoded in AMPL. In the transcription procedure, the problem is discretized by means of a simultaneous optimization approach based on collocation over finite elements. Finally, the automatically generated AMPL description may be executed and solved by a numerical NLP algorithm. For this purpose we have used IPOPT.

Case Studies The prototype tools have been used to formulate and solve a start-up problem for a plate reactor system. The plate reactor is conceptually a tubular reactor located inside a heat exchanger, and offers excellent flexibility, since it is reconfigurable and allows multiple injection points for chemicals, separate cooling/heating zones and easy mounting of temperature sensors. In this case study, an exothermic reaction, $A+B \longrightarrow C$, was assumed. The reactor was fed with a fluid with a specified concentration of the reactant A. The reactant B was injected at two points along the reactor.

The primary objective of the start-up sequence was to transfer the state of the reactor from an operating point where no reaction takes place, to the desired point of operation. This problem is challenging, since the dynamics of the system is fast and unstable in in some operating conditions. In

addition, the temperature in the reactor must be kept below a safety limit, in order not to damage the hardware.

Optimal control and state profiles were calculated off-line and then used as feedforward and feedback signals in a PID-based mid-ranging control system.

The experiences from using the JModelica compiler in this project are promising, in that the tools enable the user to focus on formulation of the problem instead of, which is common, encoding of the problem. For more details on this case study, see [Haugwitz et. al. 2007].

The JModelica compiler is also used in two Master's thesis projects, which concerns optimization of dynamic vehicle models. The first project deals with race track optimization, where the problem is to minimize the lap time given the track curvature and a dynamic vehicle model. In the second project, the problem being studied is calibration of simple vehicle models.

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

Inducing Stable Oscillations in Nonlinear Systems by Feedback

Researchers: Rolf Johansson, Anders Robertsson in cooperation with Prof. A. Shiriaev, Umeå University

This 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 a 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.

Active Control of Compressor Systems Based on New Methods of Nonlinear Dynamic Feedback Stabilization

Researchers: Rolf Johansson, Anders Robertsson in cooperation with Prof. A. Shiriaev, Umeå University

This project deals with a number of facts related to the output feedback stabilization of the Moore-Greitzer compressor model. We show that quadratic feedback stabilization of the surge subsystem of the three-state Moore-Greitzer compressor model, which ensures an absence of additional equilibria in the augmented with stall dynamics closed loop system, implies convergence of all solutions to the unique equilibrium at the origin. Then some steps in developing such output feedback controller for surge subsystem are discussed, and a family of controllers is presented. Based on our new theoretical results on integrability, stability, nonlinear dynamic output feedback control, we wish to pursue active control application to compressor systems and experimental verification.

Control and Real-Time Computing

Projects on networked embedded control, real-time techniques in control system implementation, and control of real-time computing systems.

Feedback Based Resource Management and Code Generation for Soft Real-Time Systems (FISS2)

Researchers: Mikael Lindberg, Anton Cervin, and Karl-Erik Årzén in collaboration with Ericsson.

FISS2 is an VINNOVA/Ericsson project within the so called Swedish Telecom-initiative. The topic of the project is reservation and feedback-back resource management in mobile multimedia terminals.

The long term goal of the project is to learn and understand how feedback may be applied to soft-real time system in order to increase stability and performance. The project consists of two main related tracks: Feedback Based Resource Management Design and the implementation of a mechanism that allows isolation of resource usage for a set of parallel of activities. The focus will be on restricting CPU and network usage. With isolation mechanisms in place a feedback control system is placed on top, to manage the distribution of resources to achieve optimal system utilization. The test system will be implemented on a standard Linux kernel. An number of steps may be identified.

Isolation How to design a programming model that allows for isolation and virtualization of a given set of properties, for example, CPU utilization, bus bandwidth usage, etc.

Feedback Under the assumption that a given set of properties may be isolated and control, how shall the real resources be distributed and shared in order to achieve optimal behaviour according to some defined metric.

Component Design Given isolation and feedback, it is now possible to use these mechanisms to devise a component model, with support for hierarchical composition with predictable behaviour.

The project is strongly related to the New EU FP7 project ACTORS on Adaptivity and Control of Resources in Embedded Systems that started in February 2008.

Reconfigurable Ubiquitous Networked Embedded Systems (RUNES)

Researchers: Martin Ohlin, Peter Alriksson, Dan Henriksson, Anton Cervin, 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 in September 2004 and ended in August 2007. 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 have extended the TrueTime toolbox with support for simulation of wireless battery-powered nodes. We have also extended 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 robot, the RBbot. The objectives of the project were to develop a test case for control and localization over sensor networks and investigate the performance that can be achieved using state of the art sensor network technology such as Tmote Sky motes with ZigBee radio communication.

A strong focus in the RUNES project has been a road tunnel disaster scenario. During 2007 the work in RUNES has focused on developing a large physical and simulated implementation of this scenario. Within WP6, the work package about control in RUNES, a mobile robot-based sub-scenario is being developed in which autonomous mobile robots are sent into the tunnel acting as mobile radio gateways that are used to ensure connectivity within the tunnel network. In Lund an ultrasound-based localization system has been developed. Each mobile robot is equipped with an ultrasound transmitter and each stationary tunnel-network sensor node is equipped with an ultrasound receiver. By periodically emitting a radio packet and an ultrasound pulse from the robot, it is possible for each sensor node that receives this, to calculate its distance to the robot. When this is done the distance measurements are sent back to the robot and used to calculate its position and orientation using an Extended Kalman filter, in which also dead reckoning from the wheel encoder sensors is included. In order to handle localization of multiple robots a CSMA scheme is used to avoid contention. The system was

successfully demonstrated at the final review meeting at Ericsson in Kista in July 2007.

Lund is also active in WP7 of RUNES. Here we are developing the TrueTime simulation tool for wireless sensor network and MANET applications. A TrueTime model of the physical tunnel scenario was developed during 2007.

Design of Embedded Systems (ARTIST2)

Researchers: Toivo Henningsson, Mikael Lindberg, Martin Kjaer, 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, and
- Co-Design Tools for Control, Computing, and Communication

During 2007 the two following main events were organized by the cluster:

- Graduate course on Embedded Control, Lund, 7-11 May
- 2nd International ARTIST Workshop on Control for Embedded Systems, Univ of Illinois, Urbana-Champaigne, May 31 - June 1, 2007

EUROSYSLIB

Researchers: Philip Reuterswärd, Anton Cervin, and Karl-Erik Årzén in collaboration with Dynasim.

The ultimate objective of EUROSYSLIB is to make Modelica the de-facto standard language for embedded system modelling and simulation. In order to support this major product lifecycle management effort, the EUROSYSLIB consortium, composed of 20 European partners, is committed to delivering a large set of high-value, innovative modelling and simulation libraries based on the freely available Modelica object-oriented modelling language. The role of Lund University is to develop a network simulation library for Modelica with features that are similar to the network blocks in TrueTime simulator developed by Lund.

LUCAS Center for Applied Software Research

Researchers: Karl-Erik Årzén, Rolf Johansson, Anders Robertsson, Anton Cervin, Dan Henriksson, Martin Ohlin, 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 research groups at LTH:

- Computer Science
- Communication Systems, and
- 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.

Control of Computer Server Systems

Researchers: Anders Robertsson, Martin Ansbjerg Kjær, Karl-Erik Årzén, and Björn Wittenmark, in cooperation with Maria Kihl and Mikael Andersson, Department of Telecommunications, Lund University. Dan Henriksson graduated during 2006 and was for the academic year 2006/2007 postdoc at UIUC, working in cooperation with Lui Sha and Tarek Abdelzaher, Department of Computer Science, University of Illinois Urbana Champagne. Mikael Andersson defended his PhD thesis in May 2007.

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 Here 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.

Periodic and Event-Based Control over Networks

Researchers: Anton Cervin, Toivo Henningsson, Erik Johannesson, Karl Johan Åström

In this project, we investigate the timing aspects of networked control and focus on the interplay between network scheduling and control performance. We study the fundamental trade-offs that exist between sampling rates, delays, and jitter in networked control. We want to be able to answer questions such as "What level of control performance can be achieved using time-triggered vs priority-based communication protocols?", "How can impact of network-induced jitter be handled in control design?", and "How can primitives suitable for control be included in existing and new communication protocols?"

A very promising approach to more efficient usage of the network bandwidth is event-based control. The idea is to communicate measurement and control signals only when something unexpected and significant has happened in the system. We are investigating how this approach compares to ordinary, periodic control, and how event-based sampling and control can be incorporated in network scheduling algorithms.

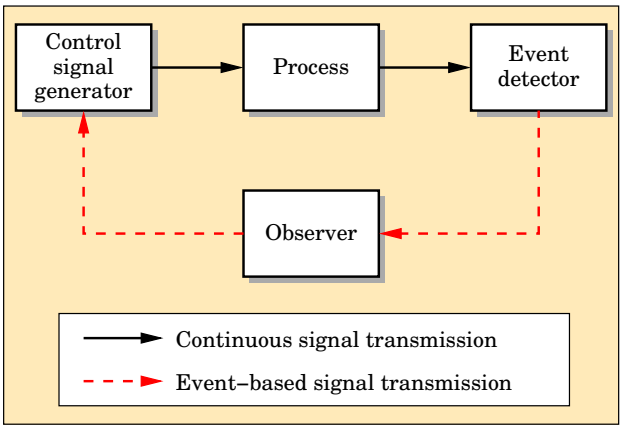


Figure 5.4 Av event-based controller structure

During 2007, we have continued to explore sporadic event-based control, that is, event-based control with a specified minimum inter-event time. Such an inter-event time is needed to implement the controller in a real-time system. Focusing on first-order stochastic systems, we have previously shown that sporadic control can give both better performance and lower resource when the controller is executed more seldom. We have recently shown that this result holds also when there is delay, jitter, and measurement noise in the system.

For higher-order systems, the analysis of event-based control systems is more challenging. One possible controller structure in shown in Figure 5.4. The event detector samples the state of the process when the output passes a certain threshold. The control signal generator calculates its output based on intermittent state updates from the observer and on linear feedback around an internal process model. Assuming constant load disturbances, we have calculated the period of the resulting limit cycle as a function of the magnitude of the disturbance. This information can be used to introduce integral action in the controller.

Process Control

Research is done in cooperation with pharmaceutic, pulp and paper as well as chemical process industry.

PID Control

Researchers: Karl Johan Åström, Olof Garpinger, Tore Hägglund, and Per-Ola Larsson

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 last is "Advanced PID Control", published in 2005. The research is currently focused on the following topics:

A simple dead-time compensator A PID controller combined with a simple dead-time compensator is investigated. The motivation for the project is that this new controller structure may be as easy to tune as a PID controller, provided that model-based tuning rules are used. The performance of the new controller will be compared with the performance of the PID controller, and simple tuning rules will be derived.

Relation between control signal properties and robustness measures In a realistic setting, fast response to load upsets are restricted by e.g. limitations on actuator devices, noise characteristics of measured signals, and process variations. Thus, this should be incorporated in the design of a controller. An analysis concerning the optimization constraint in the PID design in this project and in the project “Decentralized Structures for Industrial Control” has been performed. It has shown that analytical expressions relating the M_S and M_T circles and the control signal magnitude and activity exist to a certain extent. Large robustness margins give small control signal activities and the opposite holds for small robustness margins. Thus, the proposed PID parameter optimization do take required control signal properties into consideration.

Software tools for design of PID controllers "Surface plot from the PID design tool" A new, interactive and easily modifiable software tool for robust PID design has been developed at the department. The tool has been programmed in Matlab and the goal is to find the controller that minimizes the IAE value during a load disturbance, while applying robustness constraints in terms of M-circles. The program has been made

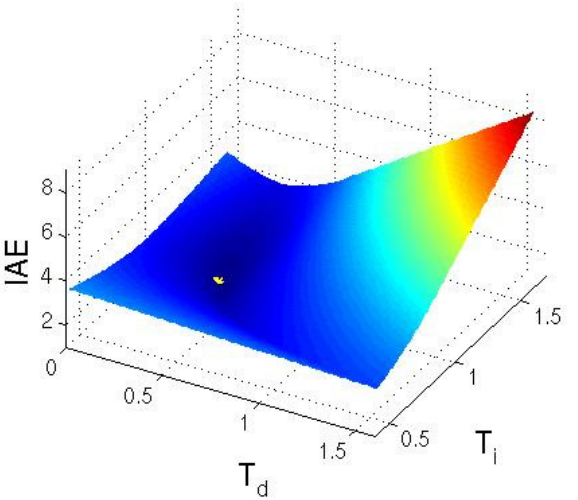


Figure 5.5 Surface plot from the PID design tool

with focus on being user-friendly as well as robust and will hopefully be included in an educational auto-tuner in the future. The figure on this page shows a plot from the program, depicting the IAE cost as a function of the integral time and the derivative time in a PID controller. The minimum is shown by the yellow mark in the figure. The current research aims at making the software more suitable for the purpose of controlling a real plant. This is done by including tuning the time constant of a low pass filter situated at the measurement signal. The purpose is to set a bound for the variance of the control signal, induced by measurement noise. By this modification, we hope to make the D-part of the PID controller more accepted in process control.

The aim is also to make the software tool free to download in the future. Interacting learning modules for PID control We are also developing 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 5.6 Steam cylinder temperature measuring

New Control Strategies in the Dryer Section of the Paper Machine

Researchers: Jenny Ekvall and 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.

Active Control of Combustion Oscillations in Gas Turbines
Researchers: Rolf Johansson, Martin A. Kjær in cooperation with CECOST (Prof. Rolf Gabrielsson, Dr. Jens Klingmann, Prof. Tord Torisson) 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 LPP (Lean Premixed Prevaporised) combustion the incoming fuel is mixed prior to combustion with the air stream delivered by the compressor. The fuel is diluted by the air and hence 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 a 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. Acoustic waves can be described by the wave equation arising from modeling of pressure and mass flow dynamics. It is well known that the operating range of pressure and flow divides into a dynamically stable part (with fairly high mass flow) and an unstable region. Depending on the configuration of the system, different types of instability can arise, and two of such has been studied; surge and rotating stall.

Using nonlinear, low order models, these types of instabilities have been generated and studied. Expanding the model with actuation (valve control of the output flow and pressure adding device) and assuming measurements of flow and pressure, controllers have been designed to stabilize the system in the low flow region. Nonlinear control methods have proved satisfactory in performance and robustness, and attempts to include adaptation to parameter variations have also been successful. A classic experiment for demonstration and experiments of flame behavior in a resonant cavity was proposed by P. L. Rijke in 1858. In the currently used modification, the Rijke tube is equipped with microphone and load speaker for experiments with active control and suppression of the thermoacoustic oscillations. A simplified dynamical model has been derived, describing the dynamical relationship between the loudspeaker-generated pressure and the pressure near the microphone. The model

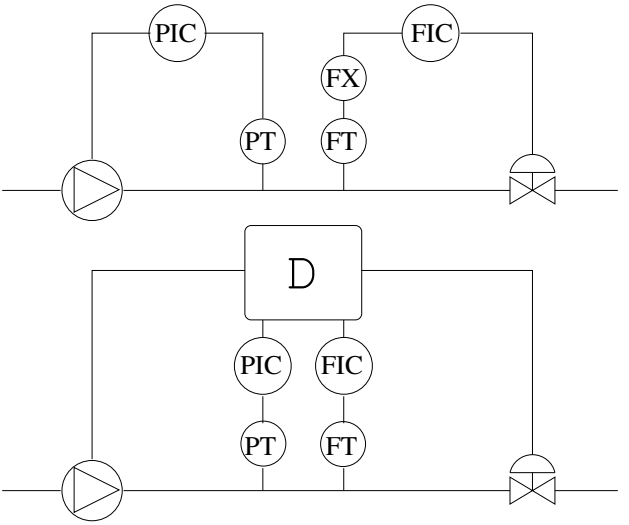


Figure 5.7 Conventional control of coupled systems (upper) and control with decoupling (lower)

includes the coupling between the acoustic properties of the tube and the properties of the flame, and predicts oscillations with constant amplitude. Using control design and analysis methods, the oscillations are suppressed using acoustic feedback. This experiment shows the potential of active control in a combustion chamber.

Decentralized Structures for Industrial Control

Researchers: Olof Garpinger and 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 have 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.

During 2007, the work has been focused on the PID design method and the software has been developed considerably. This part of the project is presented in more detail in the project ”PID Control”. Collaboration with ABB has also been extended through a master-thesis project dealing with implementation aspects.

Performance Monitoring and Diagnosis

Researchers: Tore Hägglund and Per-Ola Larsson

A performance index based on control specifications In the summer 2007, a new project concerning diagnosis of control loops was initiated. The diagnosis is built around a so called performance index that indicates the health of the loop. A majority of the today available performance indices are related to optimal performance of the loop, with some underlying criteria such as minimum variance and LQG-control. In many situations it is impossible to meet such an optimal criteria due to e.g. lack of process knowledge, requirements of a too heavy control signal activity, and restricted control structure. Instead, the aim of this ongoing project is to develop a performance index that is related to a specified satisfying control performance that is possible to meet. The initial tuning of the loop is used as reference in the index calculation. Although, explicit controller structure and parameters are not to be known by the index algorithm, neither is any a priory knowledge of the process assumed available. In the project, it has been shown that modeling of the closed loop using only process output data, gives an opportunity to calculate such an index.

Backlash estimation Stiction and backlash in control valves are the major problem at the loop level in process control plants. There are two aspects of the problem. First of all, the nonlinearities deteriorate the control performance. Secondly, the loops facing these problems often remain undiscovered by the personnel in process control plants. There are several procedures for automatic stiction detection available and used in industrial plants today.

A new method for detection and estimation of backlash in control loops has been developed. The detection procedure is based on normal operating data. It is not assumed that the output from the backlash is measured. The procedure is automatic in the sense that no information has to be provided from the user to run the procedure. Since an estimate of the dead band caused by the backlash is provided by the procedure, the procedure gives all information needed to compensate for the backlash. The procedure has been tested in industry and is patent pending.

New Control Strategies for a Novel Heat Exchange 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 new Alfa Laval Plate Reactor, now being developed by Alfa Laval AB. Innovative process design leads to vastly improved control capabilities, allowing increased productivity, efficiency and safety.

Background and process description In the chemical industry of today, the batch reactor is the most common reactor type. However is it unsuitable for highly exothermic reactions due to its limited heat transfer capacity. The reactant solutions have to be diluted with water to reduce the amount of energy released during the reaction. After the reaction, separation is necessary to remove the excess water of the product solution. Alfa Laval AB is currently developing a new kind of reactor technology, the Alfa Laval Plate Reactor. The Plate Reactor is a plate heat exchanger of new design, where one side is used as a chemical continuous reactor and the other side is filled with a cooling/heating medium.

A typical reaction can be stated as: $A+B \longrightarrow C+D$. The primary reactant A enters the main inlet of the reactor. The secondary reactant B is then added in multiple inlet ports along the reactor, to distribute the heat from the exothermic reaction.

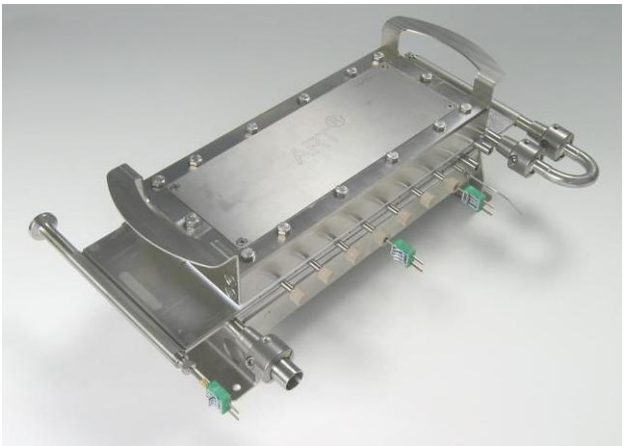


Figure 5.8 The laboratory version of the Plate Reactor

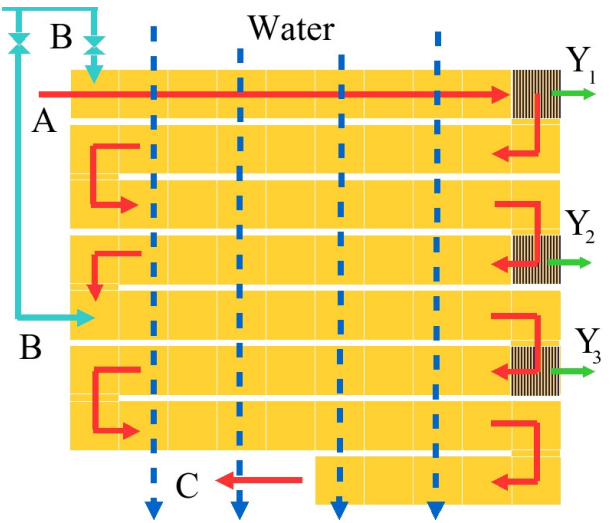


Figure 5.9 A sketch of the first rows inside the plate reactor.

The process has a much higher heat transfer capacity, so solutions of higher concentrations can be used leading to less separation need. The process will also have higher productivity, more efficient reaction and a safer process. The reactor construction will be very flexible, where the number of plates, injection sites and sensor locations can be varied to

fit various reactions. The new internal sensors inside the reactor, which directly monitor the process, lead to better process knowledge and together with internal injections sites create a new way of process control.

Realize the full potentials with advanced process control The Plate Reactor is very interesting from a control point of view. It has internal sensors enabling accurate information about the reactor temperature and also indirectly concentrations inside the reactor. With multiple injection points the heat 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 process uncertainties, disturbances and variations in inlet feed conditions. One crucial part of the control system is the start-up procedure. The objectives of the control system can be summarized as:

The objectives of the control system:

- Utilize the reactor maximally in a safe way
- Achieve and maintain desired operating conditions
- Robustness towards uncertainties and disturbances in the process item Fast and safe start-up/shut-down

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. 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 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.

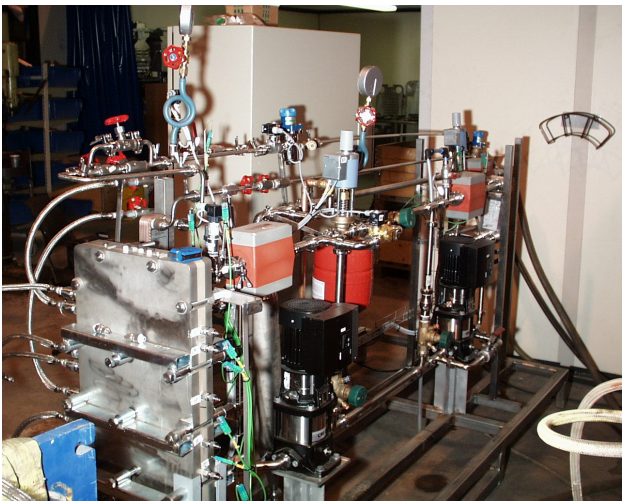


Figure 5.10 The laboratory set-up.

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.

The article “Process control of an Open Plate Reactor”, about the plate reactor and the control system, was presented at the IFAC World Congress in Prague in 2005 and it achieved the best control application paper award. An extended version of the paper was published in Control Engineering Practice during 2007.

Activities during the year The focus of the research has been on dynamic optimization to generate start-up trajectories and designing a mid-ranging feedback structure to improve the robustness towards process uncertainties. The plate-reactor has been used as a case study for the development of the Optimica language, an automatic code generation tool to support dynamic optimization. The research has been summarized in the PhD thesis of Staffan Haugwitz.

Robotics

Robotics offers both theoretical and practical challenges. Our main research are in motion and compliance control, control system architectures and various different sensor fusion problems.

ProViking FlexAA: Flexible and Accurate Manufacturing Operations Using Robot Systems

Researchers: Anders Blomdell, Mathias Haage, Rolf Johansson, Klas Nilsson, Tomas Olsson, Anders Robertsson, Lund University in cooperation with Mats Björkman, Henrik Kihlman, 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 today's 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.

SMErobot

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

The project SMErobot is lead by Fraunhofer – Institut für 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 today's 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.

Automotive systems

Projects devoted to vehicle dynamics and combustion control run in cooperation with major car manufacturers.

Figure 5.11 DaimlerChrysler test vehicles, an S-500 and an A-class.

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 mitigation. 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 conditions. This complicates the task of finding a controller to mitigate rollover. In Figure 5.11 see DaimlerChrysler test vehicles.

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.

There are several choices of actuators for vehicle dynamics control, including brakes, active steering and active suspension. In this project the focus is on the use of brake systems allowing individual assignment of braking force (so-called EBD systems). A key issue in the development of control algorithms is how to use the available actuators in an optimal way. A technique known as Control Allocation is used to map 'abstract' control commands (such as total forces and moments) onto actuator inputs. This is done by solving a constrained optimization problem in real time.

Model-Based Road Friction Estimation

Researchers: Brad Schofield and Tore Hägglund at Lund University, Jacob Svendenius at Haldex, Fredrik Bruzelius and Stefan Solyom at Volvo Cars.

Road vehicles rely strongly on friction. Their large masses, when moving at high speeds may cause fatal damage if steer-ability is lost. The forces determining the motion of the vehicle are generated at the tire-road contact patch and are highly dependent on a sometimes abruptly changing friction. A large safety margin is required while driving in conditions of reduced or uncertain friction, but this is often not sufficiently regarded by drivers. Modern vehicle control systems such as anti-lock brakes and Electronic Stability Programs (ESP) can, to some extent, correct for mistakes made by the driver, but the performance of such systems always depends on the quality of the information available to them.

Many investigations show a correlation between the road condition and the risk of accidents. The output from a road friction estimator might be used by a device that warns the driver about a bad or suddenly altered road condition. Information about friction can also be used to enhance the functionality of control systems within the vehicle or sent to a global infrastructure that receives and transmits information about the roads.

Work on model-based road friction estimation is undertaken within the Road Friction Estimation project, RFE II, involving members from SAAB, VTI, Volvo Technologies, Volvo Cars, Lund University, Luleå Technical University and Haldex Brake Products. The project is a part in the national research programme Intelligent Vehicle Safety Systems (IVSS). RFE II is a continuation of the original RFE project.

The aim of the RFE II project is to estimate the friction between tire and road surface and to evaluate and optimize the reliability as well as the delay of the estimation. The model-based estimation subproject is aimed at deriving algorithms for on-board estimation of the friction based on measurements from already available sensors in the vehicle. The main focus is on longitudinal tire force excitations, although expansion to lateral excitation is one of the additional aims of RFE II.

Preliminary tests and evaluations have been performed at test-tracks in Hällered and in Arjeplog, Sweden. The tests show promising results. See Figure 5.12.

Figure 5.12 Vehicle testing in northern Sweden.

Tire Modelling and Friction Estimation

Researchers: Jacob Svendenius and Björn Wittenmark in cooperation with Haldex and Modelon.

New system technologies are continuously improving the performance of vehicles regarding comfort, stability, environmental stresses, and safety. Novel sensors are developed and used together with advanced control algorithms and faster and more accurate actuators to help the driver to maneuver the vehicle in a safer way. The physical traction limit set by the friction between the tires and the road can, however, not be overridden. The behavior of tires is, therefore, an important issue since it determines the possibilities to control the vehicle. See Figure 5.13.

One essential task for the vehicle control system is to be able to fully utilize these friction limits. Another is to assist the driver to choose an adequate driving style, adapted to the actual conditions. A method to derive the tire forces for simultaneous braking, cornering and camber, by combining empirical models for the pure behavior of each of respective action is investigated in this project. The method is based on the physical foundation brought by the simple, but well-suited brush model theory. The pure-slip tire models can be given as empirical models or as raw tabular data. The implementation is verified to be well-working and computationally sound and good results are obtained in validation with the available empirical data.

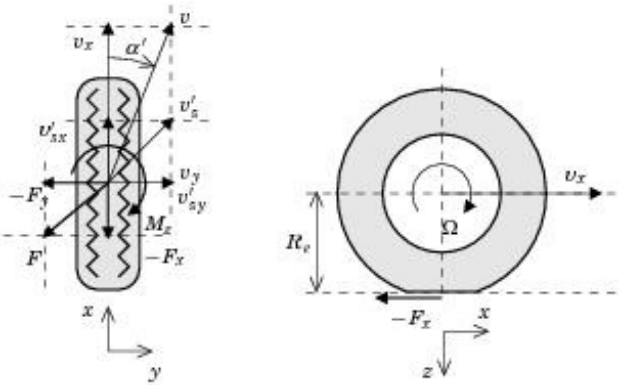


Figure 5.13 Kinematics of a tire during braking and cornering.

A new type of on board brush-model based friction-estimator using the local measurements on the vehicle is also developed. A major invention is the way of collecting the measurements into bins, such that the available data used for optimization is evenly weighted along the force and slip axis.

Experimental data has been collected and evaluated to ensure the validity of the brush model during certain conditions. The estimator has been implemented and validated on a personal car. The wheel speed signal is an essential signal in many system applications. Based on problems observed during performed measurements, a few ways to reduce the noise on the signal, without adding any phase shift or time delay, are developed in the project.

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.

During 2007, work focused on combining various different actuators for combustion control. One approach was to combine injection of fuel into the intake port with fuel injected directly into the cylinder. With different fuels used in the two injection systems, the set-up leaves much freedom for influencing the combustion to ensure a safe operation of the engine while optimizing efficiency and emissions. Another approach is to control combustion using both fuel injection parameters, such as start of injection, and amount of exhaust gas recirculation to steer the engine to a very narrowly specified range where all specifications–e.g., on emissions and efficiency–are met.

KCFP, Closed-Loop Combustion Modeling and Control

Researchers: Rolf Johansson, Anders Widd in cooperation with Assoc. Prof. Per Tunestål and Prof. Bengt Johansson, Div. Combustion Engines

The Competence Center Combustion Processes at Lund University focuses on research of combustion processes between conventional HCCI (Homogeneous Charge Compression Ignition) and classical Otto and Diesel engines.

Project aims:

- System identification of combustion processes under closed-loop control.
- Development of algorithms hardware implementation suitable for ASICs and FPGA.
- Control-oriented modeling and simulation of combustion processes.

In addition to aspects of modeling related to thermodynamics, chemical combustion kinetics, and engine operation, careful attention is required for control-oriented combustion modeling and the interactions among dynamics, control, thermodynamics and chemical combustion properties. Modeling of engine-load transients as well as thermal transients also belong to this important domain of modeling. Progress in this area is

important and necessary for successful and robust control such as model-predictive control.

Biomedical Systems

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 intraatrial 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.

Balance Laboratory

Researchers: Rolf Johansson in cooperation with Prof Måns Magnusson, Dr. Per-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 multisensory feedback control (visual, 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.

6

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 and Scholarships

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,
AstraZeneca,
DaimlerChrysler,
COMAU S.p.A.,
Castings Technology International,
Dynasim AB,

Ericsson,
Fraunhofer-Institut f. Produktionstechnik und Automatisierung,
Fraunhofer-Institut f. Systemtechnik und Innovationsforschung,
German Aerospace Center-Institute of Robotics and Mechatronics,
Güdel,
Haldex AB,
Instituto di Tecnologie Industriali e Automazione, Italy,
KPS Rinas,
KUKA Roboter GmbH & Co. Maschinenfabrik,
Modelon AB,
Novozymes Biopharma AB,
Perstorp AB,
Pro-Support B.V.,
Prospektiv Gesellschaft f. betriebliche Zukunftsgestaltung GmbH,
Rinas ApS,
Tetra Pak Processing Systems AB,
Toyota Motor Corporation,
ZF Lenksysteme,
Visual Components Oy,
Volvo Powertrain, Inc.,
Wayfinder Systems AB,

and we got scholarships from the following foundations:

Foundation of Per Westling,
Foundation Sigfrid and Walborg Nordkvist,
Foundation Aeryleanska Traveling Scholarship,
Hakon Hansson,
Jacob Letterstedt,
Knut and Alice Wallenberg,
Royal Academy of Sciences,
Royal Physiographic Society,
Sweden Japan Foundation.

European Collaboration

During 2007 the department was involved in several projects in the 6th Framework 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

The department was also involved in the European ITEA 2 project EUROSYSLIB.

During 2007 several of the professors at the department have been strongly involved in writing proposals for the European Commission 7'th framework project calls. This has been very successful and we will during 2008 participate in at least one IP one new NoE and four new STREP projects.

7

Dissertations

Five PhD theses were defended this year, by Jacob Svendenius, Tomas Olsson, Ather Gattami, Staffan Haugwitz, and Johan Åkesson.

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

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

Tire Modeling and Friction Estimation

Jacob Svendenius
PhD dissertation, April 20, 2007

Opponent: Prof. David Limebeer, Imperial College, London, Great Britain. Committee: Prof. Fredrik Gustafsson, Linköping University, ISY, Linköping, Sweden; Dr. Mats Andersson, Volvo Technology, Gothenburg, Sweden; Prof. Torsten Söderström, Uppsala University, Uppsala, Sweden.

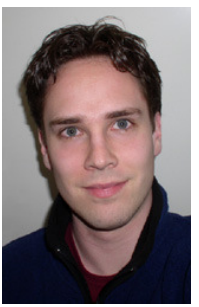
New system technologies are continuously improving the performance of vehicles regarding comfort, stability, environmental stresses, and safety. Novel sensors are developed and used together with advanced control algorithms and faster and more accurate actuators to help the driver to maneuver the vehicle in a safer way. The physical traction limit set by the friction between the tires and the road can, however, not be overridden. The behavior of tires is, therefore, an important issue since it determines the possibilities to control the vehicle. One essential task for the vehicle control system is to be able to fully utilize these limits. Another is to assist the driver to choose an adequate driving style, adapted to the actual conditions.

A method to derive the tire forces for simultaneous braking, cornering and camber, by combining empirical models for the pure behavior of each of respective action is presented in the thesis. The method is based on the physical foundation brought by the simple, but well-suited brush model theory. The pure-slip tire models can be given as empirical models or as raw tabular data. The implementation is verified to be well-working and computationally sound and good results are obtained in validation with the available empirical data.

A new type of on board brush-model based friction-estimator using the local measurements on the vehicle is also proposed. A major invention is the way of collecting the measurements into bins, such that the available data used for optimization is evenly weighted along the force and slip axis. Experimental data has been collected and evaluated to ensure the validity of the brush model during certain conditions. The estimator has been implemented and validated on a personal car.

The wheel speed signal is an essential signal in many system applications. Based on problems observed during performed measurements, a few ways to reduce the noise on the signal, without adding any phase shift or time delay, are discussed in the thesis.

High-Speed Vision and Force Feedback for Motion-Controlled Industrial Manipulators



Tomas Olsson
PhD dissertation, May 4, 2007

Opponent: Prof. Joris De Schutter, Katholieke Universiteit, Heverlee, Belgium. Committee: Docent Danica Kragic, KTH, Stockholm, Sweden; Docent Mikael Norrlöf, Linköping University, Linköping, Sweden; Dr. Nicolas Andreff, IFMA, Aubière Cedex, France.

Over the last decades, both force sensors and cameras have emerged as useful sensors for different applications in robotics. This thesis considers a number of dynamic visual tracking and control problems, as well as the integration of these techniques with contact force control. Different topics ranging from basic theory to system implementation and applications are treated.

A new interface developed for external sensor control is presented, designed by making non-intrusive extensions to a standard industrial robot control system. The structure of these extensions are presented, the system properties are modeled and experimentally verified, and

results from force-controlled stub grinding and deburring experiments are presented. A novel system for force-controlled drilling using a standard industrial robot is also demonstrated. The solution is based on the use of force feedback to control the contact forces and the sliding motions of the pressure foot, which would otherwise occur during the drilling phase.

Basic methods for feature-based tracking and servoing are presented, together with an extension for constrained motion estimation based on a dual quaternion pose parametrization. A method for multi-camera real-time rigid body tracking with time constraints is also presented, based on an optimal selection of the measured features. The developed tracking methods are used as the basis for two different approaches to vision/force control, which are illustrated in experiments.

Intensity-based techniques for tracking and vision-based control are also developed. A dynamic visual tracking technique based directly on the image intensity measurements is presented, together with new stability-based methods suitable for dynamic tracking and feedback problems. The stability-based methods outperform the previous methods in many situations, as shown in simulations and experiments.

Optimal Decisions with Limited Information

Ather Gattami
PhD dissertation, June 8, 2007

Opponent: Prof. Geir Dullerud, University of Illinois, Urbana, USA. Committee: Docent Ulf Jönsson, KTH, Stockholm, Sweden; Prof. Vincent Blondel, Université Catholique de Louvain, Louvain-la-Neuve, Belgium; Prof. Anders Helmersson, ISY, Linköping University, Linköping, Sweden.

This thesis considers static and dynamic team decision problems in both stochastic and deterministic settings. The team problem is a cooperative game, where a number of players make up a team that tries to optimize a given cost induced by the uncertainty of nature. The uncertainty is modeled as either stochastic, which gives the stochastic team problem, or modeled as deterministic where the team tries to optimize the worst case scenario. Both the stochastic and deterministic static team problems are stated and solved in a linear quadratic setting. It is shown that linear decisions are optimal in both the stochastic and deterministic framework.

The dynamic team problem is formulated using well known results from graph theory. The dynamic interconnection structure is described by a graph. It appears natural to use a graph theoretical formulation to examine how a decision by a member of the team affects the rest of the members.

Conditions for tractability of the dynamic team problem are given in terms of the graph structure. Tractability of a new class of information constrained team problems is shown, which extends existing results. For the presented tractable classes, necessary and sufficient conditions for stabilizability are given.

The state feedback $\mathcal{H}_2$ and $\mathcal{H}_\infty$ infinity dynamic team problems are solved using a novel approach. The new approach is based on the crucial idea of disturbance feedback, which is used to separate the controller effect from the measured output, to eliminate the controller's dual role.

Finally, a generalized stochastic linear quadratic control problem is considered. A broad class of team problems can be modeled by imposing quadratic constraints of correlation type. Also, power constraints on the control signals are very common. This motivates the development of a generalized control theory for both the finite and infinite horizon case, where power constraints are imposed. It is shown that the solution can be found using finite dimensional convex optimization.

Modeling, Control and Optimization of a Plate Reactor

Staffan Haugwitz
PhD dissertation, October 12, 2007

Opponent: Prof. Karlene Hoo, Texas Technical University, Lubbock, USA. Committee: Prof. Sten B. Jøregensen, DTU, Lyngby, Denmark; Dr. Mikael Lundh, ABB, Västerås, Sweden; Dr. Matz Lenells, Växjö University, Växjö, Sweden.

A new chemical reactor, the Alfa Laval Plate Reactor, is being developed by Alfa Laval, a Swedish world-leading heat exchanger company. The plate reactor combines the high-heat-transfer capabilities of plate heat exchangers with the efficient mixing and reaction control typical of micro reactors. With this new concept, highly exothermic reactions can be produced using more concentrated reactants and more accurate temperature control. This will reduce the reaction time and the need for downstream separation, thus saving energy and reducing the impact on the environment.

The focus of this thesis is to develop and apply control methods to take advantage of the full potential of the novel plate reactor concept. A nonlinear model of the reactor is derived based on first principles to conduct a system analysis and enable model-based control. The physical model allows a detailed investigation of the potential control inputs and how the process design and choice of inputs may affect the control design.

Two control concepts are examined, decentralized control using multi-loop PID controllers and centralized control using Model Predictive Control. The concepts are evaluated and compared in terms of design methods, performance and practical aspects. A cooling system is designed and experimentally verified, where a mid-ranging control structure is implemented to increase the operating range of the hydraulic equipment.

The start-up control problem is challenging due to process uncertainty, highly nonlinear dynamics and input and temperature constraints. The dynamics and the constraints are easily captured by the process model in the optimization problem. The open question is how to address the process uncertainty. Here, robustness to uncertainty is achieved by introducing state-space constraints in the optimization formulation, which decrease the sensitivity of the optimal solution. The start-up control problem has been approached from two sides, a time-driven continuous approach and an event-driven hybrid approach.

Some of the results are specific for the plate reactor, but many parts may be generalized to other applications, for example the decentralized and centralized control design, the start-up/transition control design and use of mid-ranging control to handle two-input one-output systems.

Tools and Languages for Optimization of Large-Scale Systems

Johan Åkesson
PhD dissertation, November 30, 2007

Opponent: Prof. Lorenz Biegler, Carnegie Mellon University, Pittsburg, USA. Committee: Prof. Alf Isaksson, Linköping University, Linköping, Sweden; Docent Bernt Nilsson, Lund University, Lund, Sweden; Dr. Peter Aronsson, Linköping University, Lund, Sweden.

Modeling and simulation are established techniques for solving design problems in a wide range of engineering disciplines today. Dedicated computer languages, such as Modelica, and efficient software tools are available. In this thesis, an extension of Modelica, Optimica, targeted at dynamic optimization of Modelica models

is proposed. In order to demonstrate the Optimica extension, supporting software has been developed. This includes a modularly extensible Modelica compiler, the JModelica compiler, and an extension that supports also Optimica.

A Modelica library for paper machine dryer section modeling, DryLib, has been developed. The classes in the library enable structured and hierarchical modeling of dryer sections at the application user level, while offering extensibility for the expert user. Based on DryLib, a parameter optimization problem, a model reduction problem, and an optimization-based control problem have been formulated and solved.

A start-up optimization problem for a plate reactor has been formulated in Optimica, and solved by means of the Optimica compiler. In addition, the robustness properties of the start-up trajectories have been evaluated by means of Monte-Carlo simulation.

In many control systems, it is necessary to consider interaction with a user. In this thesis, a manual control scheme for an unstable inverted pendulum system, where the inputs are bounded, is presented. The proposed controller is based on the notion of reachability sets and guarantees semi-global stability for all references.

An inverted pendulum on a two wheels robot has been developed. A distributed control system, including sensor processing algorithms and a stabilizing control scheme has been implemented on three on-board embedded processors.

8

Honors and Awards

Karl Johan Åström was elected *Doctor Honoris Causa* at Tokyo Denki University, Japan in September.

Karl Johan Åström and **Tore Hägglund** received the *Raymond D. Molloy Award* from ISA—The Instrumentation, Systems, and Automation Society, for being the best-selling ISA authors of the year 2006.

Ather Gattami received the *Swedish Research Council postdoctoral fellowship grant* for two years studies at the Laboratory for Information and Decision Systems, MIT, Boston, USA.

Rolf Johansson was elected *Fellow of Kungliga Fysiografiska Sällskapet (Royal Physiographic Society)*, Section of Medicine, April 2007,

Rolf Johansson was appointed *Professeur Invité*, Laboratoire des Signaux et Systèmes (LSS)—CNRS, Supélec & Université de Paris-Sud XI, Gif-sur-Yvette, France, June 2007.

Anders Robertsson was appointed as *Excellent Teaching Practitioner (ETP)* at the Pedagogic Academy of LTH, Lund.

Anders Robertsson also got a scholarship for *Visiting Professor* at Universidad Politécnica de Valencia, Spain in July.

9

Personnel and Visitors

Personnel

During 2007 the following persons have been employed at the department. The list shows the *status of December 2007* 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 *(part time)*

Associate Professors

Anton Cervin *(from February)*
Charlotta Johnsson *(from February)*
Anders Robertsson *(from February)*

Researchers

Johan Åkesson *(from December)*
Ather Gattami *(from July)*

Research Engineers

Leif Andersson
Anders Blomdell
Rolf Braun

PhD Students

Johan Åkesson *(until November)*
Peter Alriksson
Isolde Dressler
Jenny Ekvall
Olof Garpinger
Ather Gattami *(until June)*
Pontus Giselsson
Staffan Haugwitz *(until October)*
Erik Johannesson
Maria Karlsson
Martin A. Kjær
Larsson, Per-Ola
Mikael Lindberg *(from August)*

Karl Mårtensson
Oskar Nilsson
Martin Ohlin *(until September)*
Tomas Olsson *(until May)*
Toivo Perby Henningsson
Mikael Petersson
Brad Schofield
Aivar Sootla
Jacob Svendenius *(until April)*
Andreas Wernrud
Anders Widd

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.

Carlos Martinez Belinchon *November 13, 2006–April 1, 2007*
Universidad Politécnica, Madrid

Georgios Kotsalis *From March, 2007*
MIT, USA

Jan Maciejowski *August 19–August 24, 2007*
Cambridge University, England

Craig Fletcher *May 23–June 5, 2007*
Melbourne University, Australia

Gonzalo Farias *May 1–June 31, 2007*
UNED, Spain

Richard Murray *July 29–June 6, 2007*
California Institute of Technology, Pasadena, USA

Alexander Kurzhanski *September 4–September 8, 2007*
Moscow State University, Russia

Sergei V. Gusev *October 24–October 27, 2007*
St. Petersburg State University, Russia

Graham Goodwin *October 23–October 27, 2007*
University of Newcastle, Australia

Visiting Students

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

David Barrio-Vicente *until April*
Universidad de Valladolid, Spain

Fabrio Arata *until May*
Politecnico di Milano, Italy

Marzia Cescon *from July*
Università degli studi di Padova, Italy

Tommaso Bresciani *from August*
Politecnico di Milano, Italy

10

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

PhD, 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. In November 2007, Johan defended his PhD thesis entitled "Languages and Tools for Dynamic Optimization of Large Scale Systems". Based on the results in the thesis, Johan has developed the JModelica compiler. An extension of this compiler can translate a high level formulation of an optimization problem, along with a Modelica model description, into a format suitable for numerical optimization algorithms. The work also includes a language extension of Modelica, entitled Optimica, in which a high-level description of a dynamic optimization problem can be specified. During 2007, Johan supervised, in cooperation with Modelon AB, two master's thesis projects: "Vehicle Path Optimisation" (Henrik Danielsson) and "Automatic Calibration of Vehicle Models" (Henrik Hultgren and Henrik Jonassson).

Alriksson, Peter

MSc, graduate student since June 2003. His research interests are in estimation of hybrid and distributed systems, with special focus on sensor networks. During the summer of 2007 a large scale sensor network demo was developed at Ericsson as part of the RUNES project. A small scale demo was also done at the European Control Conference as part of a tutorial session.

His teaching responsibilities include being a teaching assistant in the courses Control Theory and Automatic Control (Basic Course). Peter has also been co-supervising a master thesis started in February 2007.

Årzén, Karl-Erik

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

Leader for the cluster on control for embedded systems within 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). He has been responsible for and taught the undergraduate course on Real-Time Systems and the Project Course in Automatic Control. He is partly or fully involved in the supervision of three PhD students.

Bernhardsson, Bo

PhD 1992, Professor 1999, on leave for industry work since 2001. In 2007 he worked 20% at the Department and 80% at Ericsson Mobile Platforms in Lund. Bo's research interests are in linear systems, practical applications of control theory, and the connection between communication and control theory. During the year he held two PhD courses, in linear systems and robust control. He was also external reviewer at a licentiate thesis at KTH and acted as advisor for two master thesis projects and one PhD student.

Cervin, Anton

Associate Professor, PhD (2003); joined the department in 1998. Anton's research interests include real-time systems, networked control, event-based control, and computer tools for analysis and simulation of controller timing. During 2007, he has worked in his research project "Periodic and event-based control over networks", funded by the Swedish Research Council. He has also been involved in various activities within the ARTIST2 Network of Excellence on Embedded Systems Design, including lecturing within the Graduate Course on Embedded Control Systems. As Chairman of SNART, he was Program Chair of Real-Time in Sweden 2007. He has also been a lecturer in the basic-level course Systems Engineering.

Dressler, Isolde

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

Garpinger, Olof

MSc, graduate student since August 2005. Olof is involved in the project "Decentralized Structures for Industrial Control", which is funded by The Swedish Research Council (VR). The research concerns automatic tuning of systems with two inputs and two outputs (TITO systems). Besides this, Olof has developed a new Matlab based software for design of IAE optimal PID controllers with robustness constraints. This work will be presented at the IFAC World Congress in 2008. Olof has also been teaching assistant in the Nonlinear Control course as well as in the Real Time System course during 2007.

Gattami, Ather

PhD, MSc, postdoc since June 8, 2007. Ather Gattami's interests include optimization and optimal control, convex analysis, decision theory, game theory, and information theory with applications to decisions with limited information over graphs.

Ather has been teaching in various courses at the department such as "Automatic Control", "Nonlinear Control", "Adaptive Control", and "Mathematical Modeling". Ather has also been supervising a Master's Thesis project.

Giselsson, Pontus

MSc, graduate student since November 2006. During the first year Pontus has spent most of his time on courses. He has also been a teaching assistant in the basic courses Automatic Control and Systems Engineering.

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 was during 2007 the LTH vice rector of international affairs.

During 2006 he taught the basic course together with the course Control Theory.

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.

He leads a project on the control of a special type of continuous chemical reactors 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

Graduate student since August 2002. Staffan has been working with Per Hagander on the project "New control strategies for a novel heat exchange reactor". The project aimed at improving process control of chemical reactors, especially the new Alfa Laval Plate Reactor, which is being developed by Alfa Laval AB. The focus has been to develop new control methods to take advantage of the flexible configuration of the reactor and to be able to use its full potential. Staffan presented his thesis "Modeling, Control and Optimization of a Plate Reactor" on the 12th of October. He is now working for Borealis AB in Stenungsund to develop nonlinear MPC controllers for their poly-olefin reactors.

Hägglund, Tore

Professor, PhD (1984). Has been at the department since 1978 except for four years when he worked for 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, control loop monitoring and diagnosis.

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. He has also developed a new method for backlash detection that is patent pending.

Henningsson Perby, Toivo

MSc, graduate student since August 2005. His research interests are in event based, distributed and embedded control and estimation. Toivo is working on event based control for information constrained systems. During 2007 he also co-supervised a master's thesis project on GPS navigation, and was a teaching assistant in the Project Course and the Real-Time Systems course.

Johannesson, Erik

MSc, graduate student since May 2006. His research interests are in control and estimation problems where communication is limited between different parts of the system. This is also related to a certain problem in event-based control, which he has studied together with Toivo Henningsson and Anton Cervin.

During the spring, Erik was a teaching assistant for the course in Computer-Controlled Systems, as well as in the Project course. In the end of the year, he started supervising a Master's thesis that will be completed during 2008.

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 Power-train, Volvo Car Corporation and Scania CV AB. He is responsible for the two courses FRT041 System Identification and FRTN15 Predictive Control. Together with Dr. Måns Magnusson he leads research at the Vestibular Laboratory, Dept. Otorhinolaryngology, Lund University Hospital.

Johnsson, Charlotta

Charlotta Johnsson holds a position as Associate Professor. Her research is focused upon Batch Control Systems and Manufacturing Operations System. Charlotta got her PhD degree at the Department, in March 1999, with the thesis "A Graphical Languages for Batch Control". After dissertation, Charlotta joined Orsi Automazione S.p.A., later part of Siemens A&D, and worked in Genoa, Italy for 4.5 years.

During the year, Charlotta has been co-responsible for the course "Technology, Strategy and Structure" given for the Technology Management program at Lund University and she actively participated in the course "Packaging Logistics" given at LTH. Charlotta acted as the examiner for one master thesis project performed in cooperation with AstraZeneca, Södertälje.

Charlotta is currently on maternity leave.

Karlsson, Maria

MSc, graduate student since August 2005. She is working with Professor Rolf Johansson in the project Diesel-HCCI in a Multi-cylinder Engine in cooperation with Volvo Powertrain and the division of combustion engines at Lund University. During 2007, she has worked on control methods for optimizing emissions trade-offs in diesel engines. She has been a teaching assistant in the courses System Identification and Process Control.

Kjær, Martin Ansbjerg

Msc, Lic. Tech. Graduate student since August 2003. He is working in the field of active control of web servers together with Anders Robertsson. During the last year he has been focusing on queuing prediction, mostly based on simulation. His teaching activities were related to being a teaching assistant in basic automatic control courses.

Larsson, Per-Ola

MSc (2005), graduate student since January 2006. His research interest is within process control, especially in processes with delay dominant properties. Per-Ola is involved in a project together with Professor Tore Hägglund concerning tuning methods for a dead-time compensating PID controller. He has also been working on performance monitoring of closed loops, using a performance index based solely on the output of the system.

Per-Ola has been involved in teaching the basic course and some of the advanced courses.

Mikael Lindberg

MSc, graduate student since July 2007. Main research interests lie in resource management and control for embedded systems using feedback scheduling and reservation based scheduling techniques. Currently participating in the ACTORS-project, a EU sponsored project run by Ericsson Mobile Platform (EMP), and in the "Feedback Based Resource Management and Code Generation for Soft Real-Time Systems", a VINNOVA sponsored project also in co-operation with EMP.

During the fall, Mikael was a teaching assistant in the course Realtime Systems.

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.

Mårtensson, Karl

MSc, graduate student since December 2006. He has been involved in an article concerning Model Predictive Control. He has also been teaching assistant in the basic course in Automatic Control.

Nilsson, Oskar

Lic Tech, 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 nonlinear automotive models and nonlinear system identification. During the year of 2007 six months were spent at Toyota Motor Corporation, Higashi-Fuji Technical Center, Japan.

Ohlin, Martin

Lic Tech, graduate student since September 2003. During 2007 Martin was on Parental leave.

Olsson, Tomas

PhD, graduate student from December 2001 until June 2007. His main research interests are robotic force control and high-speed vision-based tracking and control. During the year he has been working with industrial force control and applications of vision-based control in the SSF/ProViking project FlexAA. In May he defended his PhD thesis titled "High-Speed Vision and Force Feedback for Motion-Controlled Industrial Manipulators". In July he left the department for a new job at ABB Robotics in Västerås, Sweden.

Rantzer, Anders

Professor of Automatic Control since 1999 and serves as head of department. He has broad interests in modeling, analysis and synthesis of control systems, with particular attention to robustness, optimization and distributed control.

Anders Rantzer is the main supervisor for several PhD students. During 2007, he taught the courses "Computer Controlled Systems" and "Mathematical Modelling" and was responsible for development of a new course on "Multivariable Control". He also served on several international scientific committees.

Robertsson, Anders

Associate professor (2007), “Docent” (2005), Research Associate (May 2003), PhD (1999). His main interest is in nonlinear control and robotics. Currently he is working on parallel kinematic robots, sensor-data integration and force control of industrial robots in collaboration with ABB Robotics. The research has been conducted with the LUCAS project, the Robotics Lab and the EU FP6-project SMErobot™. He has also been doing research on admission control systems in network nodes in cooperation with the Department of Electrical and Information Technology LTH. He has lectured the courses on Nonlinear Control and Servo Systems and acted as advisor for 3 PhD students and several Master’s Thesis projects.

He was hired as part-time Guest Lecturer at Umeå University until March 31 and he has been visiting professor at ISA, Universidad Politécnica de Valencia during July 2007.

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

Lic Tech December 2006, graduate student since August 2003. Brad’s research interests include vehicle dynamics control, in particular for active safety systems. Between 2004 and 2007 Brad was involved with the EU 6th framework project Complex Embedded Automotive Control Systems (CEmACS) which dealt with the development of active safety systems for road vehicles. Brad’s work on the project involved the design of control systems for the prevention of vehicle rollover accidents.

In late 2007 Brad began work on the Intelligent Vehicle Safety Systems (IVSS) Road Friction Estimation (RFE) II project, which involves tire modelling and the development of estimation algorithms for friction estimation in passenger cars and trucks. During 2007, Brad was a teaching assistant in the System Identification and Predictive Control courses.

Sootla, Aivar

MSc, graduate student since autumn 2006. Aivar's main research interests are model simplification, validation and reduction. He was a teaching assistant in basic Automatic Control course for undergraduate students.

Tuszyński, Agneta

Secretary at the department since 1981. She is responsible for registration of the student's and PhD student's course entries and exam results. She works with word processing in LaTeX. Agneta is also responsible for Activity Report 2007 together with Karl-Erik Årzén.

Widd, Anders

MSc, graduate student since December 2006. He is working with Professor Rolf Johansson on the project "KCFP, Closed-Loop Combustion Control", which is a cooperation with the Division of Combustion Engines. He has been a teaching assistant in the basic Automatic Control course, and has participated in the development of the new course in Predictive 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: Member of the PhD thesis committee for Mikael Andersson, May 11 at Department of Communication Systems, Lund University. Member of the PhD thesis committee for Hoai Hoang, May 14 at School of Information Science, Computer & Electrical Engineering, Halmstad University. Deputy member of the PhD thesis committee for Eva Magnusson, Dec 7 at Department of Computer Science, Lund University. Member of the PhD thesis committee for Carla Martin, Dec 10 at Dept. Informática y Automática Escuela Técnica Superior de Ingeniería Informática, Universidad Nacional de Educación a Distancia, Madrid, Spain.

Anders Rantzer: Member of PhD thesis committee for Alexandre Donzé, June 25 at Laboratoire VERIMAG, Grenoble, France. Opponent for licentiate thesis by Carl Olsson, September 17 at Lund University. Member of PhD thesis committee for Johan Nilsson, Dec 6 at Lund University.

Anders Robertsson: Faculty Opponent for Licentiate Thesis Stig Moberg, Linköping, Dec 19. Member of PhD-thesis committee for Mehdi Amirijoo, Linköping, Nov 15.

Björn Wittenmark: External reviewer for the PhD thesis by Mara Tanelli, Milano, Italy, January. Opponent for the licentiate thesis "On Feedforward Adaptation" by Magnus Nilsson at Chalmers University, June 11.

Board Member

Karl-Erik Årzén: Member of the Research Senate, Lund University. Member of the Board of the SSF Graduate School on Chemical Process Design and Control (CPDC). Member of the Strategic Management Board of the Artist2 Network of Excellence.

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

Tore Hägglund: Member of the evaluation committee on Signals and Systems at the Swedish Research Council. Member of the Education Board 2 at Faculty of Engineering, Lund University. Expert member in legal proceedings for patent at Svea Court of Appeal, 2007–2009.

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

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

Anders Rantzer: Member of the steering committee for the International Symposium on Mathematical Theory of Networks and Systems.

Björn Wittenmark: Assistant vice-chancellor (Vice president) for Lund University from March 1, 2003. Chairman Lund Laser Center. Board member of LUCAS. Board member of Gyllenstiernska Krapperupstiftelsen.

Anders Robertsson: Deputy member of "Lärarförslagsnämnd 2", LTH, Lund.

Program Chair

Anton Cervin: Program Chair for Real-Time in Sweden 2007 – the 9th Biennial SNART Conference on Real-Time Systems.

Anders Robertsson: Program co-chair and organizer of the 2nd IEEE International Workshop on Feedback Control Implementation and Design in Computing Systems and Networks (FeBID'07), Munich, Germany, June.

Book and Journal Editor

Tore Hägglund: Editor for Control Engineering Practice.

Rolf Johansson: Associate Editor, Int. J. Adaptive Control and Signal Processing. Associate Editor, Chinese Journal of Scientific Instrument, (China Instrument and Control Society). Guest Associate Editor, Special Issue on Hybrid Systems in Automotive Control 2007, International Journal of Control, Vol. 80, No. 11, 2007.

Anders Rantzer: Member of the editorial board for International Journal of Robust and Nonlinear Control. Guest editor of International Journal of Control, November 2007.

Björn Wittenmark: Member of the editorial board for Journal of Forecasting and IEE Proceedings Control Theory & Applications.

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.

Rolf Johansson: Member of IEEE EMBS Technical Committee (TC) for Biomedical Robotics. Member of Joint EMBS/RAS Advisory Committee on Biorobotics. Science Foundation Ireland (SFI), Research Frontiers Programme, February 26-27, 2007, Dublin, Ireland. Science Foundation Ireland (SFI), Research Frontiers Programme, November 5-6, 2007, Dublin, Ireland.

Charlotta Johnsson: Served as the Educational Chair of ISA District 12 (Europe, Middle East, Africa and Russia) until mid-2006. 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 working group JWG15.

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 Swedish IFAC Committee. Expert evaluator for VINNOVA and STINT.

Björn Wittenmark: Member of the Technical Committee for IFAC Adaptive Control and Learning. Reviewer for research evaluations for the Australian Research Council and Norwegian Research Council.

Member of International Program Committee (IPC)

Karl-Erik Årzén: Member of the IPC for the track on Model-Based design for Embedded Systems, DATE'07, Nice, France, April 2007. Member of the IPC for the 10th International Conference on Hybrid Systems: Computation and Control (HSCC'07), Pisa, Italy, April 2007. Member of the IPC for the Second IEEE International Workshop on Feedback Control Implementation and Design in Computing Systems and Networks (FeBID), Munich, Germany, May 2007. Member of the IPC for the special track on Computational Modeling and Simulation of Embedded Systems, Summer Computer Simulation Conference (SCSC), San Diego, CA, July 2007.

Anton Cervin: Member of the IPC for the RTNES track of the 12th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA'07).

Per Hagander: Member of IPC for the 6th IFAC Symposium on Modelling and Control in Biomedical Systems, September.

Tore Hägglund: Member of the International Program Committees for the conferences Controlo 2008 – 8th Portuguese Conference on Automatic Control in Vila Real, Portugal, and Adconip 2008 – International Symposium on Advanced Control of Industrial Processes, Jasper, Canada.

Rolf Johansson: IPC Member of Fifth IFAC Symposium on Advances in Automotive Control (AAC07) & IFAC ASME Dynamic Systems and Control Symposium, Pajaro Dunes/Seascap, California, USA, August 20-22, 2007. IPC Member, Editor and Track Co-chair of IEEE Engineering in Medicine and Biology Society Conference (EMBS'07), August 23-26, 2007, Lyon, France. IPC Member of 2007 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM 2007), ETH Zürich, Switzerland, September 4-7, 2007. IPC Member of MECHATRONICS AND ROBOTICS (M&R-2007), October 2-5, 2007 Saint-Petersburg, Russia. IPC Member of the First International Conference on Robot Communication and Coordination (ROBOCOMM 2007), Athens, Greece, October 15-17, 2007. Co-chair, 1st International Conference on Intelligent System, Information Processing, and Network (CISIPN 2007), Seoul, Korea, November 26-27, 2007.

Charlotta Johnsson: Serves as a Program committee member for the 3rd International Conference on Interoperability for Enterprise Software and Applications (IESA-07), March 28-30, 2007, Madeira Island, Portugal.

Anders Rantzer: Member of the IPC for European Control Conference 2007 (ECC07). Member of the IPC for 7th IFAC Symposium on Nonlinear Control Systems (NOLCOS07).

Björn Wittenmark: Member of the International Programme Committee of the IFAC Workshop on "Adaptation and Learning in Control and Signal Processing" (ALCOSP'07), St Petersburg, Russia, August 29-31. Member of Selection Committee for the Control Engineering Practice (CEP) Paper Prize.

Longer Visits

Under this heading longer external visits of a research or teaching nature are reported.

Johan Åkesson: During January 2007, Johan Åkesson visited, for two weeks, Prof. Lorenz T. Biegler's research group at Carnegie Mellon University, Pittsburgh, USA. During the visit, Johan presented his work on Optimica, and discussed particular methods of dynamic optimization.

Karl-Erik Årzén: Gave a one week course on Embedded Control Systems at UNED, Madrid in April. Invited lecturer in the one week Artist2 summer school on embedded systems in Suzhou, China in August.

Oskar Nilsson: Spent six months at Toyota Motor Corporation, Higashi-Fuji Technical Center, Japan, where research concerning model reduction was performed.

Anders Robertsson: Got a scholarship for visiting Professor at Universidad Politécnica de Valencia, Spain, where he stayed during July 2007. The topic of research was on control system architectures and contact force control of industrial robots, which was conducted together with Professor Angel Valera, UPV, Spain.

Brad Schofield: Visited DaimlerChrysler Research and Technology for three weeks in March 2007. The purpose of the visit was implementation of control algorithms for experimental validation in test vehicles.

11

Publications and Conference Contributions

This year 1 book, 2 book contributions, 1 proceedings, 17 journal papers, and 32 conference papers have been published.

Many of the publications can be retrieved from:

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

Books

Block, Daniel J., Karl Johan Åström, and Mark W. Spong: *The Reaction Wheel Pendulum*. Synthesis Lectures on Control and Mechatronics, Princeton, NJ, May 2007.

Book Contributions

Åström, Karl Johan: "Event based control." In *Analysis and Design of Nonlinear Control Systems: In Honor of Alberto Isidori*. Springer Verlag, 2007.

Olsson, Tomas, Rolf Johansson, and Anders Robertsson: "Force/vision based active damping control of contact transition in dynamic environments." In *Dynamical Vision*, vol. LNCS 4358/2007 of *Lecture Notes in Computer Science*. Springer-Verlag, Berlin / Heidelberg, May 2007. ISBN 978-3-540-70931-2, pp. 299-313.

Proceedings

Cervin, Anton, Ed.: *RTiS 2007—Proceedings of Real Time in Sweden 2007, the 9th Biennial SNART Conference on Real-Time Systems*, Västerås, August 2007.

Journal Papers

Årzén, Karl-Erik, Antonio Bicchi, Gianluca Dini, Stephen Hailes, Karl Henrik Johansson, John Lygeros, and Anthony Tzes: "A component-based approach to the design of networked control systems." *European Journal of Control*, **13:2-3**, June 2007.

Åström, Karl Johan: "Early control development in Sweden." *European Journal of Control*, **13:1**, pp. 7–19, June 2007.

Bengtsson, Johan, Petter Strandh, Rolf Johansson, Per Tunestål, and Bengt Johansson: "Hybrid modelling of homogeneous charge compression ignition (HCCI) engine dynamic—A survey." *International Journal of Control*, **80:11**, pp. 1814–1848, November 2007.

Collado, J., R. Lozano, and Rolf Johansson: "Using an observer to transform linear systems into strictly positive real systems." *IEEE Transactions on Automatic Control*, **52:6**, pp. 1082–1088, June 2007.

de Maré, Lena, Christian Cimander, Anders Elfwing, and Per Hagander: "Feeding strategies for *E. coli* cultivations demanding an enriched environment." *Bioprocess and Biosystems Engineering*, **30:1**, pp. 13–25, January 2007. Published online: November 2006, `http://dx.doi.org/10.1007/s00449-006-0090-z`.

Freidovich, Leonid, Anders Robertsson, Anton Shiriaev, and Rolf Johansson: "Periodic motions of the pendubot via virtual holonomic constraints: Theory and experiment." *Automatica*, 2007.

Gámez García, Javier, Anders Robertsson, Juan Gómez Ortega, and Rolf Johansson: "Estimacíon de la fuerza de contacto para el control de robots manipuladores con movimientos restringuidos (contact force estimation for compliant motion control)," (Contact force estimation for compliant motion control). *Revista Iberoamericana de Automática e Informática Industrial*, **4:1**, pp. 70–82, January 2007.

Hägglund, Tore: "Automatic on-line estimation of backlash in control loops." *Journal of Process Control*, **17**, pp. 489–499, 2007.

Haugwitz, Staffan, Per Hagander, and Tommy Norén: "Modeling and control of a novel heat exchange reactor, the open plate reactor." *Control Engineering Practice*, **15:7**, pp. 779–792, July 2007.

Johansson, Rolf, and Anders Rantzer: "Editorial—Hybrid systems in automotive control." *International Journal of Control*, **80:11**, pp. 1699–1700, November 2007.

Kao, Chung-Yao, and Anders Rantzer: "Stability analysis of systems with uncertain time-varying delays." *Automatica*, **43:6**, pp. 959–970, June 2007.

Kihl, Maria, Anders Robertsson, Mikael Andersson, and Björn Wittenmark: "Control-theoretic analysis of admission control mechanisms for web server systems." *The World Wide Web Journal, Springer*, **11:1-2008**, pp. 93–116, August 2007. online Aug 2007, print March 2008 (DOI 10.1007/s11280-007-0030-0 ,.

Prajna, Stephen, and Anders Rantzer: "Convex programs for temporal verification of nonlinear dynamical systems." *SIAM Journal on Control and Optimization*, **46:3**, pp. 999–1021, July 2007.

Shiriaev, Anton, Leonid Freidovich, Anders Robertsson, Rolf Johansson, and Anders Sandberg: "Virtual-holonomic-constraints-based design of stable oscillations of Furuta pendulum: Theory and experiments." *IEEE Transactions on Robotics*, **23:4**, pp. 827–832, August 2007.

Valera, Angel, F Benimeli, J Solaz, H de Rosario, Anders Robertsson, Klas Nilsson, R Zotovic, M Mellado, and E Olmo: "Industrial robot force control. Application to car ingress and egress human movement." *Int. Journal of Factory Automation, Robotics and Soft Computing*, **No 4**, pp. 33–39, October 2007.

Velut, Stéphane, Andreas Castan, Kevin A. Short, Jan Peter Axelsson, Per Hagander, Barry A. Zditosky, Christopher W. Rysenga, Lena de Maré, and Jan Haglund: "Influence of bioreactor scale and complex medium on probing control of glucose feeding in cultivations of recombinant strains of Escherichia coli." *Biotechnology and Bioengineering*, **97:4**, pp. 816–824, July 2007. http://dx.doi.org/10.1002/bit.21294.

Velut, Stéphane, Lena de Maré, and Per Hagander: "Bioreactor control using a probing feeding strategy and mid-ranging control." *Control Engineering Practice*, **15:2**, pp. 135–147, February 2007. http://dx.doi.org/10.1016/j.conengprac.2006.05.009.

Conference Papers

Åkesson, Johan: "Dynamic optimization of Modelica models – Language extensions and tools." In *1st International Workshop on Equation-Based Object-Oriented Languages and Tools*, Linköping Electronic Conference Proceedings, Linköping, Sweden, July 2007. Linköping University Electronic Press.

Åkesson, Johan, and Karl-Erik Årzén: "Tools and languages for modeling and optimization of large-scale dynamical systems." In *23rd IFIP TC 7 Conference on System Modelling and Optimization*, Krakow, Poland, July 2007.

Åkesson, Johan, Torbjörn Ekman, and Görel Hedin: "Development of a Modelica compiler using JastAdd." In *Seventh Workshop on Language Descriptions, Tools and Applications*, Braga, Portugal, March 2007.

Almer, S, H Fujioka, Ulf Jönsson, Chung-Yao Kao, D Patino, P Riedinger, T Geyer, A Beccuti, G Papafotiou, Manfred Morari, Andreas Wernrud, and Anders Rantzer: "Hybrid control techniques for switched-mode DC-DC converters, part I: The step-down topology." In *26th American Control Conference*, New York City, USA, July 2007.

Alriksson, Peter, Jerker Nordh, Karl-Erik Årzén, Antonio Bicchi, Alberto Danesi, Riccardo Sciadi, and Lucia Pallottino: "A component-based approach to localization and collision avoidance for mobile multi-agent systems." In *Proceedings of the European Control Conference*, Kos, Greece, July 2007.

Alriksson, Peter, and Anders Rantzer: "Experimental evaluation of a distributed Kalman filter algorithm." In *Proceedings of the 46th IEEE Conference on Decision and Control*, New Orleans, LA, December 2007.

Årzén, Karl-Erik, Antonio Bicchi, Gianluca Dini, Stephen Hailes, Karl Henrik Johansson, John Lygeros, and Anthony Tzes: "A component-based approach to the design of networked control systems." In *2007 European Control Conference*, Kos, Greece, July 2007.

Årzén, Karl-Erik, Martin Ohlin, Anton Cervin, Peter Alriksson, and Dan Henriksson: "Holistic simulation of mobile robot and sensor network applications using TrueTime." In *Proceedings of the European Control Conference*, Kos, Greece, July 2007.

Beccuti, A, G Papafotiou, Manfred Morari, S Almer, H Fujioka, Ulf Jönsson, Chung-Yao Kao, Andreas Wernrud, Anders Rantzer, M Baja,

H Cormerais, and J Buisson: "Hybrid control techniques for switched-mode DC-DC converters, part II: The step-up topology." In *26th American Control Conference*, New York City, USA, July 2007.

Buttazzo, Giorgio, and Anton Cervin: "Comparative assessment and evaluation of jitter control methods." In *Proc. 15th International Conference on Real-Time and Network Systems*, Nancy, France, March 2007.

Cervin, Anton, and Karl Johan Åström: "On limit cycles in event-based control systems." In *Proc. 46th IEEE Conference on Decision and Control*, New Orleans, LA, December 2007.

Cervin, Anton, Martin Ohlin, and Dan Henriksson: "Simulation of networked control systems using TrueTime." In *Proc. 3rd International Workshop on Networked Control Systems: Tolerant to Faults*, Nancy, France, June 2007. Invited talk.

Dressler, Isolde, Mathias Haage, Klas Nilsson, Rolf Johansson, Anders Robertsson, and Torgny Brogårdh: "Configuration support and kinematics for a reconfigurable Gantry-Tau manipulator." In *Proc. of the 2007 IEEE International Conference on Robotics and Automation (ICRA'07)*, Rome, Italy, April 2007. pp. 2957–2962.

Dressler, Isolde, Anders Robertsson, and Rolf Johansson: "Accuracy of kinematic and dynamic models of a Gantry-Tau parallel kinematic robot." In *Proc. of the 2007 IEEE International Conference on Robotics and Automation (ICRA'07)*, Rome, Italy, April 2007. pp. 883-888.

Farias, Gonzalo, Karl-Erik Årzén, and Anton Cervin: "Interactive real-time control labs with TrueTime and Easy Java simulations." In *Proc. International Multiconference on Computer Science and Information Technology, International Workshop on Real Time Software*, Wisla, Poland, October 2007.

Freidovich, Leonid, Anders Robertsson, Anton Shiriaev, and Rolf Johansson: "Stable periodic motions of inertia wheel pendulum via virtual holonomic constraints." In *Proc. 2007 European Control Conference*, Kos, Greece, 2007. pp. 3771–3776.

Gattami, Ather, and Bo Bernhardsson: "Minimax team decision problems." In *26th American Control Conference*, New York, NY, USA, July 2007.

Haugwitz, Staffan, Johan Åkesson, and Per Hagander: "Dynamic optimization of a plate reactor start-up supported by Modelica-based code generation software." In *Proceedings of 8th International Symposium*

on Dynamics and Control of Process Systems, Cancun, Mexico, June 2007.

Haugwitz, Staffan, and Per Hagander: "Analysis and design of startup control of a chemical plate reactor with uncertainties; a hybrid approach." In *Proceedings of the 16th IEEE Conference on Control Applications (CCA)*, Singapore, October 2007.

Henningsson, Toivo, and Anders Rantzer: "Scalable distributed Kalman filtering for mass-spring systems." In *Proc. 46th IEEE Conference on Decision and Control*, New Orleans, LA, December 2007.

Herreros, Alberto, Rolf Johansson, Enrique Baeyens Lázaro, Jonas Carlson, S. Bertil Olsson, and José Ramón Perán: "An algorithm for phase-space detection of the p characteristic points." In *Proc. 29th Annual International Conference of the IEEE EMBS (EMBC 2007), Lyon, France, August 23-26, 2007, pp. 2004-2007*, August 2007.

Johannesson, Erik, Toivo Henningsson, and Anton Cervin: "Sporadic control of first-order linear stochastic systems." In *Proc. 10th International Conference on Hybrid Systems: Computation and Control*, Lecture Notes in Computer Science 4416, Pisa, Italy, April 2007. Springer-Verlag.

Karlsson, Maria, Kent Ekholm, Petter Strandh, Rolf Johansson, Per Tunestål, and Bengt Johansson: "Closed-loop control of combustion phasing in an HCCI engine using VVA and variable EGR." In *Fifth IFAC Symposion on Advances in Automotive Control*, Monterey, USA, August 2007.

Kjær, Martin Ansbjerg, Maria Kihl, and Anders Robertsson: "Response-time control of single server queue." In *Proc. 46th IEEE Conference on Decision and Control*, New Orleans, LA, December 2007.

Lenain, Roland, Anders Robertsson, Rolf Johansson, Anton Shiriaev, and Michel Berducat: "A velocity estimator relying on friction observers: Application to inverted pendulum stabilization." In *7th IFAC Symposium on Nonlinear Control Systems (NOLCOS'07)*, Pretoria, South Africa, August 2007. pp. 850–855.

Ohlin, Martin, and Martin Ansbjerg Kjær: "Nice resource reservations in Linux." In *Proceedings, Second IEEE International Workshop on Feedback Control Implementation and Design in Computing Systems and Networks (FeBID'07)*, Munich, Germany, May 2007.

Olsson, Tomas, Anders Robertsson, and Rolf Johansson: "Flexible force control for accurate low-cost robot drilling." In *Proc. of the 2007 IEEE International Conference on Robotics and Automation (ICRA'07)*, Rome, Italy, April 2007. pp. 4770–4775.

Rantzer, Anders: "On prize mechanisms in linear quadratic team theory." In *Proc. 46th IEEE Conference on Decision and Control*, New Orleans, LA, December 2007.

Shiriaev, Anton, Leonid Freidovich, Anders Robertsson, and Rolf Johansson: "A method for planning orbitally stable periodic solutions in underactuated mechanical systems." In *Proceedings of Nonlinear Dynamical Analysis 2007*, St Peterburg, Russia, June 2007. Dedicated to the 150th anniversary of Academician A.M. Lyapunov.

Shiriaev, Anton, Rolf Johansson, and Anders Robertsson: "Explicit form of Lyapunov functions for a class of nonlinear feedback systems augmented with observers." In *7th IFAC Symposium on Nonlinear Control Systems (NOLCOS'07)*, Pretoria, South Africa, August 2007. pp. 1032–1037.

Svendenius, Jacob, Magnus Gäfvert, Fredrik Bruzelius, and Johan Hultén: "Experimental validation of the brush tire model." In *September 2007 Meeting of the Tire Society*, September 2007. Submitted for publication in the journal Tire Science and Technology.

Wernrud, Andreas: "Strategies for computing switching feedback controllers." In *26th American Control Conference*, New York, NY, USA, July 2007.

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Reports

During this year 5 PhD theses, have been published. The abstracts are presented in Chapter 7. Also 22 Master's theses and 6 internal reports have been completed.

Dissertations

Åkesson, Johan: *Tools and Languages for Optimization of Large-Scale Systems*. PhD thesis ISRN LUTFD2/TFRT--1081--SE, Department of Automatic Control, Lund University, Sweden, November 2007.

Gattami, Ather: *Optimal Decisions with Limited Information*. PhD thesis ISRN LUTFD2/TFRT--1079--SE, Department of Automatic Control, Lund University, Sweden, June 2007.

Haugwitz, Staffan: *Modeling, Control and Optimization of a Plate Reactor*. PhD thesis ISRN LUTFD2/TFRT--1080--SE, Department of Automatic Control, Lund University, Sweden, October 2007.

Olsson, Tomas: *High-Speed Vision and Force Feedback for Motion-Controlled Industrial Manipulators*. PhD thesis ISRN LUTFD2/TFRT--1078--SE, Department of Automatic Control, Lund University, Sweden, May 2007.

Svendenius, Jacob: *Tire modeling and Friction Estimation*. PhD thesis ISRN LUTFD2/TFRT--1077--SE, Department of Automatic Control, Lund University, Sweden, April 2007.

Master's Theses

Ajwad, Nora: "Evaluation of automatic code generation tools." Master's

Thesis ISRN LUTFD2/TFRT--5793--SE. Advisor: Jacco Koppenaal, Haldex. Examiner: Karl-Erik Årzén. Department of Automatic Control, Lund University, Sweden, April 2007.

Arvehammar, Maja: "Object oriented automation systems." Master's Thesis ISRN LUTFD2/TFRT--5785--SE. Advisor: Mattias Wallinius, Tetra Pak. Examiner: Karl-Erik Årzén. Department of Automatic Control, Lund University, Sweden, February 2007.

Barrio Vicente, David: "Modeling and balancing of spherical pendulum using a parallel kinematic manipulator." Master's Thesis ISRN LUTFD2/TFRT--5792--SE. Advisor: Anders Robertsson. Examiner: Rolf Johansson. Department of Automatic Control, Lund University, Sweden, April 2007.

Bergdahl, Tove: "Tyre pressure monitoring using sensors." Master's Thesis ISRN LUTFD2/TFRT--5790--SE. Advisor: Magnus Rau, Daimler Chrysler. Examiner: Karl-Erik Årzén, Automatic Control. Department of Automatic Control, Lund University, Sweden, April 2007.

Blom, Daniel: "HCCI engine modeling and control using conservation principles." Master's Thesis ISRN LUTFD2/TFRT--5798--SE. Advisor: Per Tunestål, Energy Sciences in Lund. Examiner: Rolf Johansson. Department of Automatic Control, Lund University, Sweden, June 2007.

Borg, Markus: "Safe programming languages for ABB automation system 800xA." Master's Thesis ISRN LUTFD2/TFRT--5801--SE. Advisor: Ola Angelsmark ABB in Malmö, Anders Nilsson Computer Science in Lund. Examiner: Karl-Erik Årzén. Department of Automatic Control, Lund University, Sweden, August 2007.

Danielsson, Henrik: "Vehicle path optimisation." Master's Thesis ISRN LUTFD2/TFRT--5797--SE. Advisor: Magnus Gäfvert, Johan Andersson Modelon in Lund. Johan Åkesson Automatic Control. Examiner: Anders Rantzer. Department of Automatic Control, Lund University, Sweden, June 2007.

Edhner, Jan: "Obstacle avoidance for mobile robots." Master's Thesis ISRN LUTFD2/TFRT--5803--SE. Advisor: Peter Alriksson, Automatic Control. Examiner: Karl-Erik Årzén. Department of Automatic Control, Lund University, Sweden, October 2007.

Gerge, Gustaf: "Implementation of IS security standards on pharmaceutical manufacturing." Master's Thesis ISRN LUTFD2/TFRT--5795--SE.

Advisor: Joakim Moby at AstraZeneca, Södertälje. Examiner: Charlotta Johnsson. Department of Automatic Control, Lund University, Sweden, June 2007.

Henricson, Johan, and Daniel Allansson: "Integrating exception handling in machine development." Master's Thesis ISRN LUTFD2/TFRT--5786--SE. Advisor: Mattias Wallinius, Tetra Pak. Examiner: Karl-Erik Årzén. Department of Automatic Control, Lund University, Sweden, February 2007.

Hersenius, Patrik: "Towards and understanding of the dynamics and energy efficiency of the human heart by mathematical modeling." Master's Thesis ISRN LUTFD2/TFRT--5787--SE. Advisor: Håkan Arheden and Einar Heiberg, Lund Hospital. Examiner: Rolf Johansson. Department of Automatic Control, Lund University, Sweden, February 2007.

Hoffstedt, Carl: "Distributed system control with FlexRay nodes in commercial vehicles." Master's Thesis ISRN LUTFD2/TFRT--5805--SE. Advisor: Anders Lindqvist Haldex AB, Landskrona. Examiner: Anton Cervin. Department of Automatic Control, Lund University, Sweden, November 2007.

Hultgren, Henrik, and Henrik Jonasson: "Automatic calibration of vehicle models." Master's Thesis ISRN LUTFD2/TFRT--5794--SE. Advisor: Magnus Gäfvert, Johan Andersson Modelon in Lund. Johan Åkesson Automatic Control. Examiner: Anders Rantzer. Department of Automatic Control, Lund University, Sweden, June 2007.

Jönsson, Jesper: "Lab-data based process control—comparing SPC and automatic control." Master's Thesis ISRN LUTFD2/TFRT--5804--SE. Advisor: Krister Forsman, Perstorp AB. Examiner: Tore Hägglund. Department of Automatic Control, Lund University, Sweden, October 2007.

Kusnadi, Daniel: "TrueTime in Scicos." Master's Thesis ISRN LUTFD2/TFRT--5799--SE. Advisor: Karl-Erik Årzén. Examiner: Anton Cervin. Department of Automatic Control, Lund University, Sweden, June 2007.

Lundstedt, Henrik: "Improved methods for GPS navigation." Master's Thesis ISRN LUTFD2/TFRT--5802--SE. Advisor: Anders Görtz Wayfinder Systems AB, Toivo Henningsson Automatic Control. Examiner: Karl-Erik Årzén. Department of Automatic Control, Lund University, Sweden, October 2007.

Malmheden, Martin: "Modegraph—A mode-automata based Modelica library for embedded control," (Modegraph—Ett modautomatbaserat Modelica-bibliotek för inbyggd reglering). Master's Thesis ISRN LUTFD2/TFRT--5808--SE. Advisor: Hilding Elmqvist, Sven Erik Mattsson Dynasim. Examiner: Karl-Erik Årzén. Department of Automatic Control, Lund University, Sweden, December 2007.

Nilsson, Martin: "Trailer stabilization with AFS." Master's Thesis ISRN LUTFD2/TFRT--5788--SE. Advisor: Christian Lundquist, ZF Lenksysteme. Examiner: Tore Hägglund. Department of Automatic Control, Lund University, Sweden, March 2007.

Nordh, Jerker: "Ultrasound-based navigation for mobile robots." Master's Thesis ISRN LUTFD2/TFRT--5789--SE. Advisor: Peter Alriksson, Automatic Control. Examiner: Karl-Erik Årzén. Department of Automatic Control, Lund University, Sweden, February 2007.

Olin, Fredrik: "Modelling of an EGR system." Master's Thesis ISRN LUTFD2/TFRT--5784--SE. Advisor: Johan Bengtsson, Volvo. Per Tunestål, Combustion Engines. Examiner: Rolf Johansson. Department of Automatic Control, Lund University, Sweden, January 2007.

Theorin, Alfred: "Implementation of an autotunable decoupling TITO controller." Master's Thesis ISRN LUTFD2/TFRT--5800--SE. Advisor: Michael Kwapisz, Mikael Petersson at ABB Malmö. Examiner: Tore Hägglund. Department of Automatic Control, Lund University, Sweden, July 2007.

Zaben, Haitham: "Utvärdering av latens och jitter för LQG och PID," (Evaluation of latency and jitter for LQG and PID controllers). Master's Thesis ISRN LUTFD2/TFRT--5807--SE. Advisor: Anton Cervin, Automatic Control. Examiner: Karl-Erik Årzén. Department of Automatic Control, Lund University, Sweden, December 2007.

Other Reports

Karlsson, Maria: "Hårda miljölagar banar väg för ny förbränningsmotor," (Strict environmental legislation leads way for new type of combustion engine). May 2007.

Lindberg, Mikael: "A survey of reservation-based scheduling." Technical Report ISRN LUTFD2/TFRT--7618--SE, Department of Automatic Control, Lund University, Sweden, October 2007.

Ohlin, Martin, Dan Henriksson, and Anton Cervin: *TrueTime 1.5—Reference Manual*, January 2007.

Svendenius, Jacob: "Validation of the brush model towards VTI-measurement data recorded at Hällered 2005." Technical Report ISRN LUTFD2/TFRT--7616--SE, Department of Automatic Control, Lund University, Sweden, January 2007.

Svendenius, Jacob: "Validation of the brush model towards VTI-measurement data recorded in Arjeplog 2006." Technical Report ISRN LUTFD2/TFRT--7617--SE, Department of Automatic Control, Lund University, Sweden, February 2007.

Tuszynski, Agneta, and Anders Rantzer, Eds.: "Automatic control 2006. Activity report." Technical Report ISRN LUTFD2/TFRT--4034--SE, Department of Automatic Control, Lund University, Sweden, April 2007.

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

Åkesson, Johan

Dynamic Optimization, Modelica, and Compilers, Invited lecture, Department of Automatic Control, Linköping University, Linköping, Sweden, March 22.

Dynamic Optimization of Modelica Models – Language Extensions and Tools, Berlin, Germany, July 30.

Tools and Languages for Modeling and Optimization of Large-Scale Dynamical Systems, In 23rd IFIP TC 7 Conference on System Modelling and Optimization, Krakow, Poland, July 23–27.

Alriksson, Peter

A Component-Based Approach to Localization and Collision Avoidance for Mobile Multi-Agent Systems, European Control Conference, Kos, Greece, July 4.

Experimental Evaluation of a Distributed Kalman Filter Algorithm, 46th IEEE Conference on Decision and Control, New Orleans, LA, USA, December 12.

Årzén, Karl-Erik

Embedded Control: Controller Implementation with Resource Limitations, Aalborg University, Denmark, January 25.

Co-design Tools for Embedded Control Systems, Aalborg University, Denmark, January 26.

Holistic Simulation of Mobile Robot and Sensor Network Applications Using TrueTime, In European Control Conference, Kos, Greece, July 4.

Wireless Sensor Networks, In Öredev Conference, Malmö, Sweden, November 13.

Åström, Karl Johan

The Hidden Technology, The Emergence and Development of Control, INRIA Grenoble, France, May 7.

Convergence of Computing, Control, and Communication, The Strategic Foundation, Stockholm, Sweden, August 7.

The Future of Control, Tokyo Denki University, Tokyo, Japan, September 14.

Smooth Strategies for Swinging Up an Inverted Pendulum, Advanced Theory and Applications of Control Systems ATACS 2007, Tokyo University of Technology, Hachiioji Seminar House, Tokyo, Japan, October 21.

Bicycle Dynamics and Control, Department of Applied Analysis and Complex Dynamical Systems, Graduate School of Informatics, Kyoto University, Kyoto, Japan, October 23.

Feedback Fundamentals, Plenary Lecture, the 11th International Conference on Mechatronics Technology, Ulsan, Korea, November 5.

Safe Manual Control of Unstable Systems with Actuator Saturation, HAM Workshop on ”Future and Perspective of Human Adaptive Mechatronics”, Ulsan, Korea, November 6.

Control of Micro-Systems, Plenary lecture, 5th COE Workshop on Human Adaptive Mechatronics, Tokyo, Japan, November 16.

Bicycle Dynamics and Control, Keio University, Tokyo, Japan, November 19.

Cervin, Anton

TrueTime for Simulation of Networked Embedded Control Systems, DATE’07 Workshop “Towards a Systematic Approach to Embedded Systems”, Nice, France, April 20.

Introduction to Control; Integrated Control and Scheduling; Control of Computer Systems; TrueTime, ARTIST2 Graduate Course on Embedded Control Systems, Lund, May 7–10.

Event-Based Control and Computing, Keynote lecture, 2nd International ARTIST Workshop on Control for Embedded Systems, Urbana-Champaign, IL, June 1.

Simulation of Networked Control Systems Using TrueTime, Keynote lecture, 3rd Workshop on Networked Control Systems: Tolerant to Faults, Nancy, France, June 20.

Simulation of Networked Control Systems Using TrueTime, Real-Time in Sweden 2007, Västerås, August 22.

Analysis and Simulation of Event-Triggered Networked Control Loops, Invited lecture, Gipsa-lab, Grenoble Institute of Technology, Grenoble, France, November 14.

Gattami, Ather

Optimal Distributed Linear Quadratic Control, Royal Institute of Technology, Stockholm, Sweden, September 20.

Linear Quadratic Control Theory for Distributed Control, Linköping University, Linköping, Sweden, October 11.

Hägglund, Tore

Process Control in Practice, Industrial course, Stockholm, Sweden, May 9–10.

Advanced PID Control, PhD course, University of Almeria, Almeria, Spain, May 14–17.

Automatic Estimation of Backlash in Valves, The 4th Nordic Process Control Workshop, Espoo, Finland, August 24.

Haugwitz, Staffan

Analysis and Design of Startup Control of a Chemical Plate Reactor with Uncertainties; a Hybrid Approach, IEEE Conference on Control Applications (CCA), Singapore, October 1.

Dynamic Optimization of a Plate Reactor Start-up Supported by Modelica-based Code Generation Software, 8th Int. Symposium on Dynamics and Control of Process Systems (DYCOPS), Cancun Mexico, June 7.

Dynamic Optimization to Achieve Robust Start-up Control of a Plate Reactor Based on Sensitivity Analysis, Nordic Process Control Workshop, Helsinki Finland, August 23.

Johannesson, Erik

Sporadic Control of First-Order Linear Stochastic Systems, Hybrid Systems: Computation and Control, Pisa, Italy, April 5.

Johansson, Rolf

Industrial Robot Force Control, World Industries Ace (WIA), Hyundai-Kia Motors Group, Changwon, Republic of Korea, March 28.

Haptic Human-Machine Interfaces in Robotics, Plenary Lecture, Evolution of Robotic Surgery in Europe—The 2007 Crafoord Conference (CC2007), Lund, Sweden, April 20.

Hybrid Control of Homogeneous Charge Compression Ignition (HCCI) Combustion Engines, Laboratoire des Signaux et Systèmes (LSS)—CNRS, Supélec & Université de Paris-Sud XI, Gif-sur-Yvette, France, June 21.

Hybrid Control of Homogeneous Charge Compression Ignition (HCCI) Combustion Engines, HYCON Annual Meeting 2007, Università degli Studi dell'Aquila, Aquila, Italy, September 28.

Force-Controlled Drilling Using Industrial Robot Assembly Operations, Plenary Lecture, Mechatronics and Robotics (M&R-2007), Saint-Petersburg, Russia, October 4.

High-Precision Force-Controlled Drilling Using Industrial Robot Assembly Operations, Invited Lecture, 1st International Conference on Intelligent System, Information Processing, and Network (CISIPN 2007), Seoul, Korea, November 26.

Johnsson, Charlotta

Enterprise Control and Manufacturing Operations, Presentation given at IET'07 (The Institution of Engineering and Technology), London, UK, November 20

Business Systems and Enterprise/Control System Integration, Seminar given in the course Packaging Logistics, Lund University, Lund, Sweden.

Kjær, Martin Ansbjerg

`Nice` *Resource Reservations in Linux,* Second IEEE International Workshop on Feedback Control Implementation and Design in Computing Systems and Networks (FeBID'07), Munich, Germany, May.

Olsson, Tomas

Flexible Force Control for Accurate Low-Cost Robot Drilling, IEEE International Conference on Robotics and Automation (ICRA'07), Rome, Italy, April 4.

Rantzer, Anders

Linear Quadratic Theory for Distributed Control—From Telescopes to Vehicle Formations, ETH, Zürich, Feb 20.

Control of Large Scale Distributed Systems, Invited lecture at the EU Information Day on Networked Embedded and Control Systems, Brussels, May 22.

Opportunities and Challenges in Distributed Embedded Control,, Invited lecture at ARTEMIS Annual Conference, Berlin, June 5.

On Distributed Control and Price Mechanisms, Plenary lecture at SIAM Conference on Control and Its Applications, San Francisco, June 30.

Linear Quadratic Theory for Distributed Control—Vehicle Formations and Trading Games, Stanford University, July 7.

A Numerical Approach to Model Simplification, Toyota Motor Company, Shizuoka, Japan, October 30.

On Distributed Control and Price Mechanisms, Invited lecture, University of Stuttgart, Germany, November 7.

On Distributed Control and Price Mechanisms, University of Maryland, USA, December 10.

On Prize Mechanisms in Linear Quadratic Team Theory, 46th IEEE Conference on Decision and Control, New Orleans, December 12.

Robertsson, Anders

Naturvetenskap-, Medicin- och Teknikdagarna, Popular science lectures at Lund University, Lund, Sweden, March 7.

Industrial Robot Force Controller, STINT-visit to South Korea, WIA, Changwong, South Korea, March 28.

Exhibition of Robotics Activities in Lund, Scandinavian Technical Fair, October 11.

Productive Robotics in Lund, Mechatronic meeting, Lund, October 11.

Response-Time Control of Single Server Queue, CDC-presentation, New Orleans, USA, December 13.

Wittenmark, Björn

IPZ Models – Tuning and Modeling, University of California, Santa Barbara, November 15.

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Seminars at the Department

Seminars presented in order of date. The seminars were given at the department during 2007, both by the staff and by invited lecturers. Dissertations and master's theses presentations are also included.

AC = Department of Automatic Control, LTH
LU = Lund University

Jan 10: **Fredrik Olin** (LU), *Modelling of EGR System.* MSc-thesis presentation.

Jan 31: **Mattias Sandberg** (KTH, Avd. Matematik, Stockholm), *Convergence of Numerical Methods for Optimal Control Using Viscosity Solutions and Differential Inclusions.*

Feb 2: **Patrik Hersenius** (LU), *Towards an Understanding of the Dynamics and Energy Efficiency of the Human Heart by Mathematical Modelling.* MSc-thesis presentation.

Feb 7: **Martin Nilsson** (LU), *Trailer Stabilization with Active Front Steering.* MSc-thesis presentation.

Feb 13: **Jerker Nordh** (LU), *Ultrasound-based Navigation for Mobile Robots.* MSc-thesis presentation.

Feb 20: **Takayuki Takahashi** (Fukushima, Japan), *Development of Robotic Systems for Human Support.*

Feb 21: **Jan Jantzen** (Ørstad, DTU), *Foundations of Fuzzy Control.*

Feb 26: **Maja Arvehammar** (LU), *Object-Oriented Automation Systems.* MSc-thesis presentation.

Feb 26: **Kajsa Karlsson, Johanna Byrlind** (LU), *New Web Based HMI Portal for Tetra Pak Equipment.* MSc-thesis presentation.

Feb 26: **Johan Henricsson, Daniel Allansson** (LU), *Integrating Exception Handling in Machine Development.* MSc-thesis presentation.

Mar 14: **Georgios Kotsalis** (MIT, USA), *Model Reduction for Hidden Markov Models.*

Mar 20: **Alfred Theorin** (LU), *Implementation of an Auto-tunable Decoupling TITO Controller.* MSc-thesis presentation.

Apr 20: **Jacob Svendenius** (AC), *Tire Modeling and Friction Estimation.* Doctoral dissertation defence.

Apr 20: **David Limebeer** (Imperial College, UK), *Steering Compensators for High-Performance Motorcycles.*

Apr 27: **David Bario-Vicente** (Universidad Valladolid, Spain), *Modeling and Balancing of Spherical Pendulum using a Parallel Kinematic Manipulator.* MSc-thesis presentation.

Apr 27: **Jesper Jönsson** (LU), *Lab-data Based Process Control - Comparing SPC and Automatic Control.* MSc-thesis presentation.

May 2: **Magnus Lindhults** (LU), *Batch Production of Biological Substances: Terminology, Methods, and Tools for Improved Batch Strategy at Novozymes Biopharma AB.* MSc-thesis presentation.

May 4: **Nicolas Andreff** (IFMA, Clermont-Ferrand, France), *Image-Based Visual Servoing of the I4R Parallel Robot without Proprioceptive Sensors.*

May 4: **Joris De Schutter** (Katholieke Universiteit Leuven, Belgium) *Constraint-Based Task Specification and Estimation for Sensor-Based Robot Systems in the Presence of Geometric Uncertainty.*

May 4: **Tomas Olsson** (AC), *Dynamic High-Speed Visual and Force Feedback for Motion-Controlled Industrial Manipulators.* Doctoral dissertation defence.

May 15: **Nora Ajwad** (LU), *Evaluation of Automatic Code Generation Tools.* MSc-thesis presentation.

May 28: **Haitham Zaben** (LU), *Utvärdering av latens och jitter för LQG och PID regulatorer.* MSc-thesis presentation.

May 31: **Richard M. Murray** (Control and Dynamical Systems, California Institute of Technology, USA), *Grand Challenges in Networked Control for Autonomous Systems.*

June 1: **Ola Dahl** (Datavetenskap, Malmö Högskola, Sweden), *Nonlinear Observers for Dynamic Vision - Algorithms and Analysis.*

June 4: **Graig Fletcher** (Department of Mechanical and Manufacturing Engineering, University of Melbourne, Australia), *RABiT, Robotics and Heavy Vehicle Tracking; Common Dynamics and Shared Principles in Control.*

June 7: **Carolyn Beck** (University of Illinois at Urbana-Champaign, USA), *Modeling and Control of Anesthetic Pharmacodynamics.*

June 7: **Geir Dullerud**, (University of Illinois at Urbana-Champaign, USA), *Automata-Switched Systems and Control over Graphs.*

June 8: **Björn Johansson** (KTH, Stockholm), *Peer-to-Peer Algorithms for Distributed Optimization in Sensor Networks.*

June 8: **Vincent D. Blondel** (Université Catholique de Louvain, Belgium), *Consensus for Agents that have Local Interactions.*

June 8: **Ather Gattami** (AC), *Optimal Decisions with Limited Information.* Doctoral dissertation defence.

June 13: **Daniel Kusnadi** (LU), *TrueTime in Scicos.* MSc-thesis presentation.

June 13: **Erik Lindegren** (LU), *Preparing The Apache HTTP Server for Feedback Control Application.* MSc-thesis presentation.

June 14: **Gustaf Gerge** (LU), *Implementation of IS Security Standards in Pharmaceutical Manufacturing.* MSc-thesis presentation.

June 14: **Daniel Blom** (LU), *HCCI Modeling.* MSc-thesis presentation.

June 15: **Henrik Jonasson, Henrik Hultgren** (LU), *Automatic Calibration of Vehicle Models.* MSc-thesis presentation.

June 15: **Henrik Danielsson** (LU), *Vehicle Path Optimization.* MSc-thesis presentation.

June 20: **Gonzalo Farias** (National University for Distance Education, Spain), *Web-Based Labs using Easy Java Simulations.* MSc-thesis presentation.

Sep 5: **Alexander B. Kurzhanski** (Moscow State (Lomonosov), University University of California at Berkeley), *On the Problem of Measurement Feedback Control.*

Sep 7: **Alexander B. Kurzhanski** (Moscow State (Lomonosov), University University of California at Berkeley, USA), *Impulse Control Synthesis, Fast Controls and Hybrid System Modelling.*

Sep 21: **Henrik Lundstedt** (LU), *Methods for Improved GPS Navigation.* MSc-thesis presentation.

Sep 25: **Jan Edhner** (LU), *Obstacle Avoidance for Mobile Robots.* MSc-thesis presentation.

Oct 8: **Patrick Borgqvist** (LU), *Modeling of A/F Sensor Output.* MSc-thesis presentation.

Oct 10: **Magnus Egerstedt**, *Graph-Based Control of Heterogeneous Robot Networks: From Controllability to Optimal Control.*

Oct 12: **Staffan Haugwitz** (AC), *Modeling, Control and Optimization of a Plate Reactor.* Doctoral dissertation defence.

Oct 12: **Karlene Hoo** (Techas Tech, USA), *Control projects at Texas Tech University.*

Oct 12: **Rasmus Olsson** (Pidab Instrumentdesign AB), *Två år i verkligheten.*

Oct 23: **Lasse Eriksson** (Helsinki University of Technology), *PID Control Design for Networked Control.*

Oct 24: **Ola Härkegård** (Saab Aerosystems), *Reglertekniska problem och lösningar i flygplansfabriken.*

Oct 25: **Sergei V.Gusev** (St. Petersburg State University, Russia), *From Yakubovich Lemma To Hilbert's 17-th Problem.*

Oct 26: **Graham Goodwin** (University of Newcastle Australia), *Developments in Networked Control.*

Nov 11: **Joe Hellerstein** (Microsoft), *Lessons Learned From Applying Control Theory to Computing Systems: A Manifesto for Resource Management Engineering.*

Nov 16: **Jesper Notander** (LU), *Intuitive Lead-Through-Programming of Steel Grinding Robots.* MSc-thesis presentation.

Nov 23: **Carl Hoffstedt** (LU), *Distributed System Control with FlexRay-nodes in Commercial Vehicles.* MSc-thesis presentation.

Nov 29: **Lorenz Biegler** (Carnegie Mellon University, Pittsburgh), *Efficient Nonlinear Programming Algorithms for Chemical Process Control and Operations.*

Nov 30: **Johan Åkesson** (AC), *Tools and Languages for Optimization of Large-Scale Systems.* Doctoral dissertation defence.

Nov 30: **Lorenz Biegler** (Carnegie Mellon University, Pittsburgh), *Process Systems Engineering at Carnegie Mellon.*

Dec 14: **Kristian Soltesz** (LU), *Control of Nonholonomic Autonomous Ground Vehicles.* MSc-thesis presentation.

Dec 18: **Mats Millnert, Johannes Pettersson** (LU), *Application of Agent Based Technology to Packaging Line.* MSc-thesis presentation.

Dec 19: **Martin Malmheden** (LU), *ModeGraph - A Mode-Automata-based Modelica Library for Embedded Control.* MSc-thesis presentation.