Activity Report: Automatic Control 2014

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Activity Report 2014

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Content

Introduction

This report describes the main activities at the Department of Automatic Control at Lund University during the period January 1 to December 31, 2014


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Linear drum boiler
-turbine models
KARL EKLUND
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Lund Institute of Technology
New Approaches
Numerical Solutio
Optimal Control Pro
KRISTER MÅRTENS
LTH
Lund Institute of Technology

AUTOMATIC CONTROL 2014

The year 2014 was an interesting year for the Department of Automatic Control, including many activites associated with research, education and external contacts.

The economy showed a turnover for 2014 (2013) of 58 MSEK (54,8 MSEK) and we are 57 (59) persons working at the department (guests not included). More about financial figures is found in the chapter *Economy.*

Today (2014) the department has 6 full time professors, 1 senior professor, 2 professors emeritus, 1 adjoint professor, 3 associate professors, 1 assistant professor, 5 research engineers, 4 administrators, 6 post-docs and 29 PhD students including one industrial PhD student. Some of these numbers include part-time positions. During the year, 4 new PhD students were admitted to the department. Moreover, Charlotta Johnsson returned after having spent almost one year of research at UC Berkeley. Pontus Giselsson extended his stay at Stanford University until December 2014. More will follow in the chapter *Staff* .

Five PhD theses by Vanessa Romero Segovia, Karl Berntorp, Daria Madjidian, Mikael Lindberg and Alfred Theorin, were completed during 2014. The total number of PhDs graduating from the department is now up to 104. Therefore, we had a celebration of the 100th thesis this spring and invited all of those who had defended their thesis including alumni at Automatic Control to a small event; more about this in chapter *Staff.*

This year there was no licentiate thesis presented.

During 2014 we gave 16 courses to 1 380 students at LTH and 57 students presented their master's theses at the department. We also arranged 6 PhD courses. More about this in the chapter *Education.*

euRobotics week is now established since 2012 and took place at the end of November. During this week in 2014, over 30 one-hour-long guided tours were arranged in the robotics lab at Lund University. The main audience consisted of about 650 school children and students of all ages from 30 different school classes in the region, but also of about 60 adults from the public (including some from within Lund University) during special sessions.

Two 5-week focus periods have been organized by the LCCC Linnaeus Center, one devoted to *Cloud Control* and one dovoted to *Dynamics and Control in Networks.* A successful midterm review of LCCC was finished in June 2014.

At the end of the year, a 5-year evaluation hearing took place in another of our projects, eLLIIT. A panel consisting of experts asked relatively general questions relating to excellence, impact, education, and renewal, and in the discussion what was already written in the report was substantially reinforced. The general atmosphere was quite friendly and the panel stressed that they were mainly evaluating the strategic research area (SRA) funding instrument as such, rather than the individual SRAs. The result of the evaluation is expected in May 2015.

We have made a major effort to bring structure to our old archives as well as to our library, where we save our printed work for coming generations. We are thankful for the support of Record Management and Archives (Arkivcentrum Syd, ASC).

Giacomo Como and Monika Rasmusson

Education 2014

Education on basic level, PhD studies and Doctoral dissertations

BASIC LEVEL

The engineering education follows the central European systems with five year program leading up to the university degree "civilingenjör" (civ. ing.), with the international title MSc.

Automatic Control courses are thought as part of the engineering curriculum in Engineering Physics (F), Electrical Engineering (E), Computer Engineering (D), Mechanical Engineering (M), Information and Communication Engineering (C), Environmental Engineering (W), Engineering Mathematics (Pi), Industrial Management and Engineering (I), Biotechnology (B), Engineering Nanoscience (N), Chemical Engineering (K) and Biomedical Engineering (BME).

During 2014 the department has been involved in courses given together with Lund University School of Economics and Management. Within this interdisciplinary cooperation a number of courses on subjects related to Technology Management were given. 19 future engineers have completed a master's thesis in pair with a future economist.

This year, in total 1 380 students passed our courses and 57 students completed their master's theses projects. A list of the master's theses is given in the *Appendix "Master's Theses".* The number of regsistered students correspond to 179 fullyear equivalents during the year. The numbers for 2013 were 1 210, 50 and 177 respectively.

In the table on the next page, our courses are listed along with the number of students who passed each course. Each course in the engineering program has its own webpage, documentation, manuals, old exams, etc. We have also information sheets about the engineering courses, the master's thesis and the doctorate program. You will find the links at www.control.lth.se/education.

TOTAL NUMBER OF STUDENTS WHO PASSED OUR COURSES 2014

Reglerteknik FRT010
(Automatic Control, Basic Course) 695

Realtidssystem FRTN01
(Real-Time Systems) 176

Prediktiv reglering FRTN15
(Predictive Control) 26

Processreglering FRTN25
(Process Control) 33

Reglerteori FRT130
(Control Theory) 32

Flervariabel reglering FRTN10
(Multivariable Control) 86

Systemidentifiering FRT041
(System Identification) 40

Systemteknik FRT110
(Systems Engineering) 64

Olinjär reglering och servosystem FRTN05
(Nonlinear Control and Servo Systems) 100

Projekt i reglerteknik FRT090
(Projects in Automatic Control) 37

Matematisk modellering FRT095
(Mathematical Modeling, Advanced Course) 37

Marknadsstyrda system FRTN20
(Market Driven Systems) 29

Fysiologiska modeller och beräkningar FRTF01
(Physiological Models and Computations) 25

Examensarbete FRT820
(Master's Thesis Project) 38

Examensarbete TMA820
(Master's Thesis Project within Technology Management) 19

TMA-kurser (Technology Management Courses)
(TMA010, TMAF10) 80

PHD STUDIES

The PhD education consists of four years of studies: 120 hp of courses and 120hp of thesis work. Since most students have 20% of department duties, the nominal time for the PhD education is 5 years. In the Swedish system there is also a possibility to do a half-time thesis called a ”licentiate”.

During 2014, no licentiate thesis was presented.

Five doctoral theses were defended during the year by Vanessa Romero Segovia, Karl Berntorp, Mikael Lindberg, Daria Madjidian and Alfred Theorin.

We have admitted Fredrik Bagge Karlsson, Martin Karlsson, Victor Millnert and Olof Troeng as PhD students during 2014.

The following PhD Courses were given in 2014

- *Linear Systems,* Bo Bernhardsson
- *Study circle in Game Theory,* Bo Bernhardsson
- *Study Circle on Robot Learning and Control,* Anders Robertsson
- *Optimal Control,* Magnus Perninge
- *Cloud Computing Resource Management,* Johan Eker
- *System identification,* Karl Johan Åström

DOCTORAL DISSERTATIONS

The Doctoral theses, of which the abstracts are presented below, are available in the entirety at www.control.lth.se/publications

PARTICLE FILTERING AND OPTIMAL CONTROL FOR VEHICLES AND ROBOTS
Berntorp, Karl

This thesis covers areas within estimation and optimal control of vehicles, in particular four-wheeled vehicles. One topic is how to handle delayed and out-of-sequence measurements (OOSMs) in tracking systems. The motivation for this is that with technological development and exploitation of more sensors in tracking systems, OOSMs gain more significance in various applications. The thesis derives a Bayesian formulation of the OOSM problem for nonlinear state-space models, when a linear, Gaussian substructure is present. This formulation is utilized when developing two particle-filter algorithms for the OOSM problem. The algorithms improve estimation accuracy and tracking robustness, compared with methods that do not utilize the linear substructure.

A second topic is sensor fusion for improved autonomy in vehicles. A novel approach to model-based joint wheel-slip and motion estimation of four-wheeled vehicles is developed. Unlike other approaches, the method explicitly models the nonlinear slip dynamics in the state and measurement equations. Excellent and consistent accuracy for all relevant states are reported, both during steady-state driving and aggressive maneuvering. The method applies to general classes of four-wheeled vehicles and it only assumes kinematic relationships.

Optimization-based control methods have found their way into automotive applications. Optimal control for vehicles typically results in control inputs that give aggressive maneuvering. Proper models are therefore crucial. An investigation on what impact different vehicle models and road surfaces have on the optimal trajectories in safety-critical maneuvers is presented. One conclusion is that the control-input behavior is highly sensitive to the choice of chassis and tire models. Another conclusion is that the optimal driving techniques are different depending on tire-road characteristics.

The conclusions motivate the design of a novel, two-level hierarchical approach to optimal trajectory generation for wheeled vehicles. The first novelty is the use of a nonlinear vehicle model with tire modeling in the optimization problem at the high level. This provides for better coupling with the low-level controller, which uses a nonlinear model predictive controller (MPC) for allocating the torques and steer angles to the wheels. This is combined with a linear MPC, which is used when the nonlinear MPC fails to converge in time.

The thesis also describes a hierarchical design flow for performing online, minimum-time trajectory generation for four-wheeled vehicles with inde-

pendent steer and drive actuation, combined with real-time obstacle avoidance. The approach is based on convex optimization. It therefore allows fast computations, both for trajectory generation and online feedback-based obstacle avoidance. The proposed method is fully implemented on a pseudo-omnidirectional mobile platform and evaluated in experiments in a path-tracking scenario.

FROM COMPETITIVE TO COOPERATIVE RESOURCE MANAGEMENT FOR CYBER-PHYSICAL SYSTEMS
Lindberg, Mikael

This thesis presents models and methods for feedback-based resource management for cyber-physical systems. Common for the scenarios considered are severe resource constraints, uncertain and time-varying conditions and the goal of enabling flexibility in systems design rather than restricting it.

A brief survey on reservation-based scheduling, an important enabling technology for this thesis, is provided and shows how modern day resource reservation techniques are derived from their real-time system and telecommunications theory roots.

Techniques for modeling components of cyber-physical systems, including both computational and physical resources, are presented. The cyclic component model, specifically designed to model common resource demanding components in smart phones, is introduced together with techniques for model parameter estimation. The topic of competitive resource management, where the different parts of the system compete for resources, is discussed using a smart phone platform as motivating example. The cyclic component model is used to form a rate-based performance metric that results in a convex optimization problem. A specialized optimization algorithm for solving this problem efficiently online and with limited precision hardware is introduced and evaluated through simulations.

A feedback control scheme for distributing resources in cases where components collaborate, i.e., where the performance metric is dependent on more than one component, is detailed and examined in a scenario where the available resource is limited by the thermal dynamics of the CPU. The scheme is evaluated through simulation of a conversational video pipeline. The thermal model is validated on a mobile robot, where it is used as part of an adaptive resource manager.

The problem of energy conservative distribution of content to a population of co-located mobile clients is used to motivate the chapter on cooperative resource management, i.e., scenarios where the participants have individual but similar goals and can benefit from sharing their partial results so that all collaborators save cost.

The model for content trading is presented in synchronous and asynch-

ronous formulations and performance is evaluated through both simulations and experimental results using a prototype implementation in an emulated environment.

LOW-RANK DISTRIBUTED CONTROL WITH APPLICATION TO WIND ENERGY

Madjidian, Daria

This thesis addresses three different topics in wind power plant operation.

Most of the research is focused on controlling a wind farm that is required to meet a power set-point. In this mode of operation, the wind turbines are able to vary their power production as long as the total power demand is met. The research investigates how this freedom can be used in order to reduce the fatigue loads experienced by the wind turbines. The problem is studied in a linear-quadratic control setting where the objective is to minimize the total fatigue load experienced by the turbines, while satisfying a requirement on their joint power production. It is shown that, under certain assumptions, the design problem can be drastically simplified. In particular, the computational effort needed to obtain the solution is independent of the number of wind turbines and the only centralized operation required to implement the optimal control law is a single summation. The research also explains the mechanisms that make power allocation schemes useful for load reduction.

Part of the research addresses wake effects in wind farms by developing a low-complexity model of the aerodynamic interaction between wind turbines. The model is used in a series of examples, where the wind turbines coordinate their power productions in order to maximize the power production of the wind farm. The examples indicate that the benefit of power coordination increases with the number of turbines in the wind farm. They also identify the underlying mechanisms behind this effect.

The last topic of the thesis is to investigate the benefits of using preview of the incoming wind speed in order to reduce structural loads on the wind turbine tower. The main focus is to understand how measurement distortion influences the achievable load reduction as well as the required length of preview. Results from high-fidelity simulations based on real wind turbine measurements indicate that the use of preview can lead to a significant reduction of tower fatigue loads and that the length of preview needed to attain the reduction does not exceed a few seconds.

CPU RESOURCE MANAGEMENT AND NOISE FILTERING FOR PID CONTROL

Romero Segovia, Vanessa

The first part of the thesis deals with adaptive CPU resource management for multicore platforms. The work was done as a part of the resource manager component of the adaptive resource management framework implemented in the European ACTORS project. The framework dynamically allocates CPU resources for the applications. The key element of the framework is the resource manager that combines feedforward and feedback algorithms together with reservation techniques. The resource requirements of the applications are provided through service level tables. Dynamic bandwidth allocation is performed by the resource manager which adapts applications to changes in resource availability, and adapts the resource allocation to changes in application requirements. The dynamic bandwidth allocation allows to obtain real application models through the tuning and update of the initial service level tables.

The second part of the thesis deals with the design of measurement noise filters for PID control. The design is based on an iterative approach to calculate the filter time constant, which requires the information in terms of an FOTD model of the process. Tuning methods such as Lambda, SIMC, and AMIGO are used to obtain the controller parameters. New criteria based on the trade-offs between performance, robustness, and attenuation of measurement noise are proposed for assessment of the design. Simple rules for calculating the filter time constant based on the nominal process model and the nominal controller are then derived, thus, eliminating the need for iteration. Finally, a complete tuning procedure is proposed. The tuning procedure accounts for the effects of filtering in the nominal process. Hence, the added dynamics are included in the filtered process model, which is then used to recalculate the controller tuning parameters.

A SEQUENTIAL CONTROL LANGUAGE FOR INDUSTRIAL AUTOMATION

Theorin, Alfred

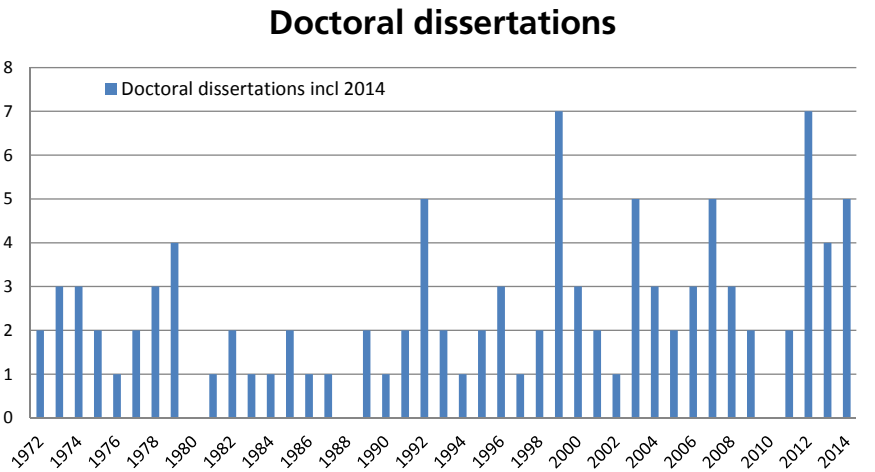
Current market trends for industrial automation are the need for customizable production, shorter time to market, and powerful global competitive pressure. Based on these trends two challenges have been identified: 1) flexible production systems and 2) integration and utilization of devices and software. Applications from both process automation, manufacturing, and robotics have been considered.

More flexible languages and tools are needed to get a flexible production system. The graphical programming language Grafchart, based on the IEC 61131-3 standard language Sequential Function Charts (SFC), is consi-

dered with the aim to make both the language and its implementation more flexible. In particular, new constructs have been added to the Grafchart language and modern compiler techniques are evaluated for JGrafchart, a Grafchart implementation, with focus on an extensible language implementation. A first step toward real-time execution of Grafchart applications is also taken to make it possible to use Grafchart for hard real-time control. High execution rates often reveal concurrency issues and thus execution concurrency has also been investigated.

Access to more data from industrial devices and software can be used to optimize production. Architectures for factory integration have been considered as this is the foundation to connect all devices and thus address the challenge of integrating and utilizing devices and software. Service Oriented Architecture (SOA) is a flexible software design methodology widely used in IT systems and for business processes. SOA service orchestration is brought to industrial automation by integrating support for both Devices Profile for Web Services (DPWS) and OPC Unified Architecture (OPC UA) in JGrafchart. Looking further, SOA 2.0 is event driven and features extremely loose coupling between components. An architecture based on SOA 2.0 where it is easy to integrate any device or software, in particular legacy devices with limited knowledge and capabilities, has been developed with focus on service choreography in industrial manufacturing. Another step toward real-time execution of Grafchart applications is integrated support for the high performance communication protocol LabComm. Additionally, it is investigated how Grafchart can be connected to Functional Mock-up Interface (FMI) for co-simulation to further address the shorter time to market trend by introducing simulation support.

The PID controller is the most common controller for industrial automation. A PID implementation has been added to a Grafchart library and a flaw with the PID algorithm has been discovered. The problem occurs for PID controllers with a derivative part when the process value saturates. The derivative part then backs off which leads to undesired changes in the control signal. This issue has been analyzed and a solution to the problem is proposed.


Doctoral dissertations
Doctoral dissertations incl 2014
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Research 2014

This chapter contains the different projects that were ongoing during 2014

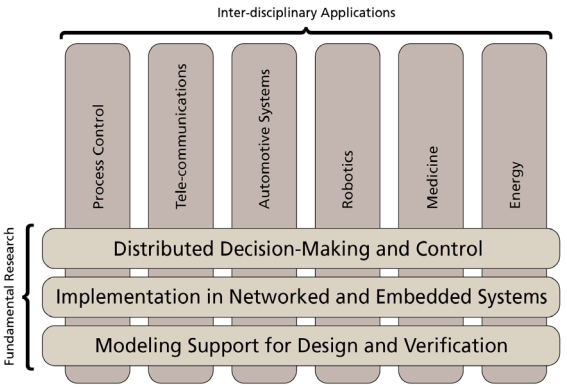
EXCELLENCE CENTERS

LCCC - LINNAEUS CENTER

LCCC is developing theory, methods and tools for control of complex engineering systems. Computer control is present in most, if not all, technical applications today, e.g., cars, robots, medical devices, industrial production, consumer electronics, computers, communication devices, traffic and transportation systems, etc. Sometimes this is called "cyber-physical systems". The research of LCCC is therefore naturally motivated by a wide range of application areas, where improved information and computing technology has enabled the use of feedback control in new and innovative ways. The vision of LCCC is to maintain a world-leading center for research on control of complex engineering systems. This vision influences LCCC's research, dissemination and outreach strategy.

LCCC is mainly devoted to fundamental research. The efforts are inspired by applications, but most results are of general nature and not application-specific. In fact, one purpose of LCCC is to transfer ideas and methodology between different fields. To meet this objective, LCCC research emphasizes the interaction between theory and applications.

During 2013-2014, the LCCC centre underwent a mid-term review. This process culminated by an onsite visit by an international evaluation panel in January 2014. The results of the review were made public in June 2014 and were very positive for the centre. The panel's report expressed appreciation for the quality of the research conducted, the vitality of the LCCC environment, and the organization of the centre. In particular, the Swedish Research Council confirmed its financial support to LCCC until the end of the project, in 2018.



Three horizontal blocks illustrate the main directions of fundamental research, and six vertical blocks illustrate the application areas. Research is pursued within the vertical and horizontal blocks as well as in the intersections. The research is led by LCCC faculty members, with competence including control, computer engineering and communications. Most PhD projects emphasize fundamental research and general purpose tools, but they usually also have an application component involving industrial partners or colleagues from other disciplines.

Focus period and Workshop in Cloud Control

Cloud Control, May 2014: LCCC workshops are organized in a 3-day format. About 20-25 speakers from academia and industry are invited for the workshop, selected for excellence and for an optimal coverage of the theme. The speakers are also encouraged to extend their stay beyond the workshop for further interaction with the local research environment. For each workshop, the research theme is chosen strategically to support the vision of a LCCC, usually with a cross-disciplinary perspective. An international scientific committee is responsible for the program.

Workshop theme: The Cloud Control Workshop was aimed to foster research in the multidisciplinary area of Cloud Control, leveraging expertise in areas such as distributed systems, control theory, autonomic computing, systems management, mathematical statistics, energy management, performance management, etc, to manage the cloud. The aim was to gather researchers from both academia and industry, and thereby promote new collaborations and ideas.

Scope: The workshop addressed challenges regarding the management and control of large-scale cloud infrastructures by bringing together the computer science community doing cloud management with the control community dealing with large-scale computing systems.

Organization and venue: The workshop was initiated by Maria Kihl (Dept. of Electrical and Information Technology, Lund University), Karl Erik Årzén (Dept. of Automatic Control, Lund University) and Erik Elmroth (Dept. of Computer Science, Umeå University). The scientific committee consisted of Maria Kihl (chair), Karl Erik Årzén, Erik Elmroth, Tarek Abdelzaher (University of Illinois at Urbana-Champaign), Jie Liu (Microsoft Research), Bruno Sinopoli (Carnegie Mellon University), Vladimir Vlassov (Royal Institute of Technology), and Giovanni Toffetti (IBM Haifa Research Lab). The local organization and interactions with workshop speakers and participants was handled by Eva Westin. The workshop was held at the Bishop's house at Lund University, May 7-9 2014.

Picture taken at the Cloud Control meeting in May 2014

Focus period and Workshop on Dynamics and Control in Networks, October 2014

The LCCC focus period on *Dynamics and Control in Networks* took place in Lund in October 2014. It spanned over five weeks with a 3-day workshop in the middle (October 15-17). The highly cross-disciplinary research theme was chosen by the LCCC board to support the strategic vision of the Centre.

The event was organized by the LCCC faculty members Giacomo Como and Anders Rantzer. The local arrangements and interactions with workshop speakers and participants was handled by Eva Westin. A scientific committee was formed, composed by Tryphon Georgiou (University of Minnesota), Steven Low (CalTech), Asuman Ozdaglar (Massahusetts Institute of Technology), Rodolphe Sepulchre (University of Cambridge), Sandro Zampieri (Università di Padova), and the organizers. The scientific committee selected other fifteen world-leading researchers in the field and invited them to give a seminar at the workshop, extend their stay during the focus period compatibly with their commitments, and nominate outstanding young researchers for an extended stay. Seventeen such researchers were selected by the scientific committee and invited to join the Center for periods of 3 to 5 weeks and to give a seminar during the focus period.

In addition to their seminar, all the participants where invited to submit open problems that could motivate and inspire the research community. The initiative was meant as a first step of a wider project to collect open research problems in Control Systems in conjunction with the 2015-16 thematic year in Control Theory and its Applications organized at the Institute for Mathematics and its Applications (IMA). The submitted problems underwent a peer review process and some selected ones were presented during the workshop. The workshop was concluded by a panel discussion moderated by Anders Rantzer.

Scientific theme: Networks, ranging from infrastructure (such as transportation, communication, and distribution networks) to social and economical networks, play an increasingly central role in many aspects of our lives. Many of the key interactions in these networks are inherently dynamic and the network connectivity and feedback pathways affect robustness and functionality. Such concepts are at the core of a new and rapidly evolving frontier of Dynamical Systems and Control.

In this new technological and scientific realm, the modeling and representation of systems and the role of feedback need to be reevaluated. Traditional thinking, which is limited to a small number of feedback loops, is no longer applicable, e.g., because of its lack of scalability. Feedback control and stability of network dynamics require new approaches. Decentralized control and distributed optimization, as well as layered architectures and plug-and-play paradigms have become of central interest.

The October 2014 LCCC Focus Period and Workshop brought together leading experts and outstanding young researchers with different scientific backgrounds in disciplines such as Control, Power Systems, Operation Research, Communication Networks, and Statistics, to share their results, compare their approaches and attempt to define the goals and boundaries of this exciting new research field.

ELLIIT - THE LINKÖPING - LUND INITIATIVE ON IT AND MOBILE COMMUNICATION

Researchers: Karl-Erik Årzén, Bo Bernhardsson, Anton Cervin, Anders Rantzer, Martina Maggio, Jerker Nordh, Anders Mannesson, Anders Robertsson, Rolf Johansson, Yang Xu, Karl Berntorp, Meike Stemman, Josefin Berner, Björn Olofsson, Jacob Antonsson, in collaboration with researchers at the Dept of Computer Science, Electrical and Information Technology, and Mathematics, Lund University, and Linköping University, Halmstad University, and Blekinge University

Funding: VINNOVA/VR (National Strategic Research Area)

ELLIIT is a network organization for Information and Communication Technology (ICT) research at Linköping, Lund, Halmstad and Blekinge, which has been created to support and enhance an internationally acknowledged research environment in these areas. The objective is scientific excellence in combination with industrial relevance and impact. It is organized within the Swedish government's strategic research support initiative.

The Department of Automatic Control participate in ELLIIT in the following ways:

Karl-Erik Årzén is vice-director for ELLIIT, Director for the Lund part of ELLIIT, and area leader for the Embedded Systems area within ELLIIT. Bo Bernhardsson is an ELLIIT professor.

The Department participate in the following ELLIIT projects:

- Integrated Scheduling and Synthesis of Networked Embedded Event-Based Control Systems
- Tools and Languages for Modeling and Optimization
- Cooperative Cyber-Physical Systems
- Navigation and Perception
- Process Learning
- Optimal Maneuvers
- Large-scale Optimization for Systems Analysis
- Enabling End-User-Centered Energy Management Systems

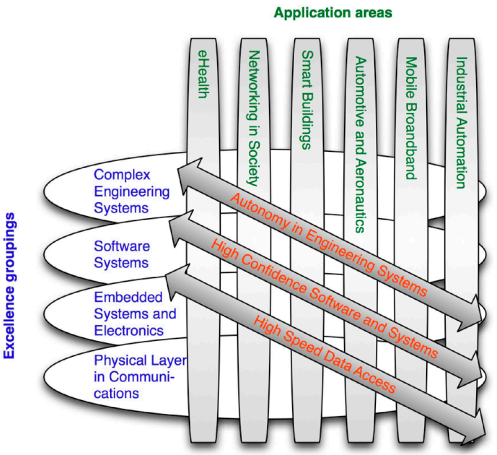


Illustration of the interaction between the themes, the application areas and the groupings (http://www.liu.se/elliit)

PIC - PROCESS INDUSTRIAL CENTER

Researchers: Olof Garpinger, Tore Hägglund, Martin Hast, Charlotta Johnsson, Ola Johnsson, Anna Lindholm, Vanessa Romero Segovia, Kristian Soltész

Funding: SSF

The Process Industry Centre PIC was founded in 2008 by the Swedish process industry and the Foundation for Strategic Research (SSF). Located at Lund University and Linköping University, the aim of PIC is to provide knowledge for the process industry to ensure future success. The academic disciplines of Chemical Engineering, Automatic Control and Production Economy form the centre together with several industrial partners from the process industry. The research projects are focused on the three topics; flexibility, controllability and availability.

The research program at Lund University, PIC-LU, is organized in a number of integrated projects. The joint research program, PIC-opic, is organised in three projects.

- **Optimal transitions**, was a collaboration between the two departments and partner companies Borealis, Siemens and Modelon AB mainly focused on flexibility, started in 2008. During phase I the project studied grade changes at a Polyethylene process at Borealis. During phase II it has studied model calibration for dynamic models for start-up of power plants at Siemens.
- **Disturbance management**, was a collaboration between Automatic Control and Perstorp AB, and availability was the research theme. It started in 2009. During phase I the project studied utility disturbances in Perstorp site at Stenungsund. In phase II it was focused on local disturbance management in low level control systems.
- **Quality by design and control**, was a collaboration between Novo Nordisk A/S, Pfizer and Chemical Engineering, started in 2008, with the main theme controllability. This project has grown and was divided in two subprojects. Subproject A has studied design and control issues while subproject B has studied modelling and model calibration.
- **Flexible design**, was a collaboration between Chemical Engineering, Lund University and K.A.Rasmussen and started in 2010, based on industrial funding. The theme was flexibility and was a research project with

additional experimental resources.

- **Fed-batch control,** was a collaboration with Automatic Control, Chemical Engineering and Novozymes. The project started in the second half of 2010 and has controllability as research theme.
- **Buffer Management and Inventories** is a collaboration between Automatic control, production economics and Perstorp AB. The aim is to combine traditional methods used in automatic control with traditional methods used for Inventory management.
- **Performance Metrics** is a collaboration between Automatic Control, production economics and Perstorp AB. The project focuses on finding production related key performance indicators suitable for use in the process industries. The project further aims at linking them to strategic initiatives and metrics of the company. The project includes active participation in the developing activities of the international ISO 22400 standard (Key Performance Indicators for Manufacturing Operations Management).
- **Economic Optimization** is a collaboration between Automatic Control, production economics and Perstorp AB. The project aims at minimizing the economic effects of utilitiy disturbances at the plant-wide level.

MODELING AND CONTROL OF COMPLEX SYSTEMS

DISTRIBUTED DECISION-MAKING AND CONTROL

Researchers: Anders Rantzer, Bo Bernhardsson, Giacomo Como, Christian Grussler, Daria Madjidian, Leonid Mirkin, Enrico Lovisari, Gustav Nilsson, Sei Zhen Khong

Funding: VR

Most of control theory has been developed in a centralized setting, where all measurements are processed together to compute the control signals. This paradigm has conceptual advantages, but also inherent limitations. In contrast, industrial practice often relies on distributed control structures. Hence, there is a strong need for theory and methodology supporting design and verification of distributed controllers. The purpose of this research area is to meet this demand.

Distributed Control using Price Mechanisms
The idea to use price mechanisms for coordination of large scale systems has a long history in economics as well as in optimization theory. Our research is exploiting similar ideas for engineering applications involving interaction between many sub-systems. In particular, we study Model Predictive Control where the optimization problem is decomposed using Lagrange multipliers. The multipliers can be viewed as prices and the optimization problem is solved iteratively through price negotiations between the subsystems. Special algorithms, called accelerated gradient methods, are exploited to speed up the iterations. Such methods are well established in the optimization literature, but using them for real-time control poses new challenges and opportunities.

Fundamental Limitations in Control Systems with Distributed Information
Theory for multivariable control has mainly been developed in a centralized setting, where all measurements are processed together to compute the control signals. This paradigm has conceptual advantages, but also inherent limitations. In particular, industrial practice often relies on distributed control structures and there is a strong need for more systematic approaches to design of such structures and the corresponding information interfaces. During the past several years we have been actively contributing to an emerging theory for control with distributed information and a better understanding for the fundamental limitations imposed by the information structure.

Control of Traffic Networks and other Monotone Systems
Traffic network models are often expressed in terms of a monotone dynamical system. This means that additional traffic can never lead to reduced congestion. The monotonicity property turns out to be very useful in analysis and synthesis of large scale systems, not only in traffic networks. Our research is devoted to fundamental questions regarding performance and robustness of traffic networks, but we are also trying to see how the methods can be applied to more general monotone systems.

Low-Rank Distributed Control
We study a class of distributed control laws, comprising a diagonal (decentralized) term perturbed by a low-rank component. A control law of this form reduces the information processing by aggregating information from all systems into a single quantity, which is then made available to each of the systems. These type of controllers appear as the optimal solution to a class of resource allocation problems in multi-agent applications, including wind farms.

ACTIVE CONTROL OF COMPRESSOR SYSTEMS

Researchers: **Rolf Johansson, Anders Robertsson, Alina Rubanova, in cooperation with Prof. Anton Shiriaev, Umeå University & NTNU, Trondheim and Dr. Leonid Freidovich, Umeå University**

Funding: VR

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.

ADAPTIVE CONTROL IN FLYING VEHICLES

Researchers: Anders Pettersson, Rolf Johansson, Anders Robertsson, Karl Johan Åström

The goal of this project is to address the question whether adaptive control can be used in products that SAAB are developing today or in the future.

There are two fundamentally different ways of controlling systems with dynamics that change over time: adaptive or robust control. The industrial baseline for flying applications today is to use robust control, which caters for the effect of parametric uncertainties, but this baseline comes with an associated loss of performance. On the other hand, with an adaptive controller it is possible to boost the performance of the closed-loop system, but then the inherent robustness may be insufficient.

Questions to be addressed:

- Can better performance be achieved for a fully/partly adaptive controller compared to a robust controller, especially with uncertain dynamics in the plant and its subsystems?
- When in a product development cycle, can adaptive steering be used? In what applications can adaptive techniques be used? Subsystems such as actuators perhaps, as well as at the top level?

For the use of adaptive control in these systems, aspects such as product safety, control law clearance and certification should be taken into account.

DISTRIBUTED CONTROL OF LARGE-SCALE WIND FARMS

Researchers: Daria Madjidian, Maxim Kristalny, Anders Rantzer, in collaboration with project partners from Aalborg University, Technion and Vestas Wind Systems

Funding: LCCC Linnaeus center

This work was initiatied within Aeolus—a European research project funded by the European Commission under FP7. The goal is to get improved efficiency and reduced maintainance costs for wind farms using real-time control and coordination of the wind turbines. Several new control paradigms have been developed, incorporating measurements from spatially distributed sensor devices. Acknowledging modelling uncertainty, the wind resource is dynamically managed in order to optimise specific control objectives.

ICT PLATFORM FOR SUSTAINABLE INFRASTRUCTURES

Researchers: Anders Rantzer, Bo Bernhardsson, Carolina Lidström, Magnus Perninge, partners at IEA and KTH

Funding: SSF

Resource-efficient infrastructures are critical for sustainable societies that want to maintain and improve today's standard of living. National and international climate goals imply large increases in renewable electricity production. This variable generation together with the increasing international trading of electricity affects the power flows in the electricity networks, which needs to be managed by system operators on local, regional and national levels. This development is in addition to the continuously increasing demand on reliable electricity supply. Traditionally this double challenge would be met by the building of new power lines. This is a simple and effective solution, but due to public reluctance to new power lines and the lengthy permission process alternatives are sought for. One general alternative is the use of automation for optimizing the use of the available network capacity. This concept - currently referred to as Smart Grids - involves investment in and installation of ICT equipment rather than physical capacity. While having been applied locally before, the situation now calls for application on a system-wide scale. Similar trends can be observed in other infrastructures.

This project aims to to design the decision-layer of an ICT platform for controlling large-scale infrastructures to operate reliably, economically, and with minimum resource waste. Special attention is given to functionality for detecting, clearing and recovering from critical operating conditions. A key component is the ARISTO real-time power system simulator, which will be used as demonstrator to illustrate the results.

NUMERICAL AND SYMBOLIC ALGORITHMS FOR DYNAMIC OPTIMIZATION

Researchers: Fredrik Magnusson in collaboration with Modelon AB, in particular Johan Åkesson and Toivo Henningsson

The target of this project is the development of collocation methods for numerical solution of large-scale, DAE-constrained, non-convex dynamic optimization problems. The project targets both optimal control and parameter estimation as well as other forms of dynamic optimization. Applications include minimization of material and energy consumption during set-point transitions in power plants and chemical processes, minimizing lap times for vehicle systems, trajectory optimization in robotics and identifying unknown parameter values of models using measurement data.

The first step of the project has been to implement state-of-the-art algorithms based on collocation methods and integrate them with the high-level, object-oriented modelling language Modelica and its extension Optimica. This allows basic users to conveniently formulate and solve problems of moderate difficulty without worrying about the details of the solution algorithms, while still allowing advanced users to tailor the algorithm as needed for complex problems. This implementation is a part of the open-source JModelica.org project. One of the important benchmarks has been based on a model of a combined cycle power plant, whose diagram is shown to the right. Two important third-party tools used within the project is CasADi, for automatic differentiation, and IPOPT, for solution of non-linear programs.

The current research direction is to symbolically process the differential-algebraic equation system describing the dynamics to create a block triangular structure of the incidence matrix by employing graph algorithms. This structure facilitates implicit analytic solution of many of the algebraic equations, removing the need to solve these iteratively. This drastically reduces the number of optimization variables, thus potentially improving both convergence speed and robustness of iterative solvers

ESTIMATION AND OPTIMAL CONTROL OF COMBINED CYCLE POWER-PLANTS

Researchers: Niklas Andersson (Dept of Chemical Engineering), Johan Åkesson, Bernt Nilsson (Dept of Chemical Engineering)

In the electricity market of today, characterized by an increasing demand for electricity production on short notice, the combined cycle power plant stands high regarding fast start-ups and efficiency. In this project, modeling, parameter and state estimation, and optimal control for efficient operation, in particular fast start-ups of combined power-plants are explored.

The basis for the work is a Modelica library containing optimization-friendly components, from which plant models are constructed. Measurement data from real plants is exploited in order to select an efficient combination of parameters to calibrate, with the goal of deriving a model with a good match between model response and data.

A critically limiting factor during start-up optimization is the stress of important components, e.g., the evaporator. In order to take this aspect into account, constraints on the stress levels of such components are explored in the start-up optimization formulation.

Control and estimation problems are solved in the project using the OSS platform JModelica.org.

LISA - LINE INFORMATION SYSTEM ARCHITECTURE

Researchers: Charlotta Johnsson, Alfred Theorin, with partners from KTH, Chalmers, Siemens, Rockwell Automation, Leax, Scania and Volvo Cars

Funding: VINNOVA FFI Sustainable Production Engineering

Future sustainable competitive production systems need to be productive and flexible, as well as environmentally friendly and safe for the personnel. There are today few system solutions that assist production management with a coherent information model and a modular system architecture that facilitates for data gathering regarding products and processes throughout the entire plant. To solve this problem the aim of this project is to develop a line information system architecture – LISA that can be used in industrial production systems in general and in automotive discrete manufacturing specifically.

Involvement: The department of Automatic Control is involved in the LISA-workpackage that assures development of new relevant standards, in order to guarantee that the automotive manufacturer's perspective is taken into account. The workpackage makes it possible to obtain feedback and interaction between the industries involved in LISA and corresponding standard committees. Examples of relevant standards currently developed are: IEC 62264 and ISO 22400.

GRAFCHART FOR INDUSTRIAL AUTOMATION

Researchers: Alfred Theorin, Charlotta Johnsson

Funding: LCCC Linnaeus Center

Grafchart has proven to be a very capable and suitable language for various control applications on both local and on supervisory level as well as for all levels of automation. It also has potential for formal descriptions, validation, and analysis. It has been used with for a wide variety of applications, e.g. batch control, discrete control, and diagnosis and the paradigm fits all of these very well.

Project aims:

- To evaluate the advantages and disadvantages of using Grafchart for industrial applications compared to the languages used today
- To improve the state of art of Grafchart

The research in this project primarily focuses on aspects that are considered important and useful for the industry. In particular the current focus is on the following topics:

- Add SOA support for Grafchart, and evaluate it in real setups. The SOA paradigm is promising approach to deal with the currently increasing complexity, increasing requirements on flexibility, and increasing demand for vertical integration.
- Real-time execution of Grafchart applications. This also enables exploring how to handle e.g. reconfiguration of running applications. Reconfiguration is taken for granted in the automation world but is rather unexplored from a research point of view.
- Improved object orientation support for Grafchart. Analyse various constructs of other modern programming languages, check if they are possible to add to Grafchart, and evaluate the benefits of adding them.

ENERGY AND BUILDING MANAGEMENT

Researchers: Josefin Berner, Meike Stemmann, Anders Rantzer

Funding: ELLIIT and LCCC

Buildings account for 40 % of total energy consumption in the European Union, in Sweden one third of the energy used is related to the building sector, and 60% of the energy used in buildings is for heating and ventilation. With a growing building sector, it is necessary to decrease the energy used by heating and ventilation in buildings, so the total energy used in the buildings sector is not increased. Improved control and management of heating and ventilation systems in buildings can help to decrease the energy usage.

This project aims at improving the temperature control in buildings, especially using PID control and Model Predictive Control (MPC). One approach involves automatic tuning of PID controllers (for more details on automatic tuning see Automatic Tuning). To perform well for temperature control, PID controllers must be tuned correctly, which is often not the case is practice. Automatic tuning can help to overcome this problem. Another approach is to investigate the temperature interaction between different rooms or zones in a building. Usually, each room would be controlled by a local controller (e.g. On/Off-control or PID). However, the temperature dynamics of adjacent rooms or zones have an influence on each other, which can be significant. To take this interaction into account, the local PID controllers are connected with a decoupling network in order to improve the overall performance. This is compared to a Model Predictive Controller controlling the temperature of all rooms at the same time.

COLLABORATION WITH THE EUROPEAN SPALLATION SOURCE

Researchers: Bo Bernhardsson, Anders J Johansson (Dept. of Electrical and Information Technology), Rolf Johansson, Olof Troeng

Funding: European Spallation Source

The European Spallation Source will be a major user facility at which researchers from academia and industry will investigate scientific questions using neutron beams.

Neutron methods provide insights about the molecular building blocks of matter not available by other means. Applications include research in life science, soft condensed matter physics, chemistry of materials, fundamental particle physics and engineering materials.

RF Field Control

The neutrons are produced by colliding high-speed protons with a rotating tungsten target. The protons are accelerated by oscillating electro-magnetic fields in more than 150 radio-frequency cavities along the 482 meter long linear accelerator. In order to avoid defocusing of the beam (which leads to activation of the accelerator structure), it is important that the amplitude and phase of the field in every cavity are kept very close to their nominal values. In order to achieve this individual feedback loops with sampling frequencies of 10 MHz will be used to regulate the fields.

The Department of Automatic Control is involved in modeling and controller design for the RF system through this group at the Department of Electrical and Information Technology.

Simulations of Cryogenic Distribution Line at ESS

The cryogenic system at ESS has been modeled in Dymola. Simulations have been made of the cool-down and warm-up of the superconducting section of the linear accelerator. Also the required capacity of the helium safety discharge system has been investigated.

Compensation of Lorenz-Force detuning

The high field strengths of the cavity fields mechanically deform the thin super conducting cavities, which changes their fundamental resonance frequency. This leads to reduced efficiency and makes the RF field control problem harder. The Department of Automatic Control will together with collaborating European universities design the control algorithm for the piezo-electric compensation system that will be used to counter-act the Lorenz force detuning.

MODEL REDUCTION OF POSITIVE SYSTEMS

Researchers: Christian Grussler, Anders Rantzer

Funding: LCCC Linnaeus center

Transportation networks, biological systems as well as heat transfer model are only a few examples for systems with the fundemental property of operating with positively measured inputs and outputs only. Typically these systems are large-scale and one way of overcoming this issue in control and simulations is to approximate the systems with the help of so-called Model Order Reduction (MOR). Unfortunately, standard MOR-methods do not preserve positivity and by that may lead to false conclusions in simulations as well as controler design.

Research in Posivity Preserving Model Order Reduction has been conducted earlier, however with strong conservatism regarding dimensionality and errors. Our main goal is to supply new approximation strategies with the incentive of weakening the current conservatism, e.g. by considering ellispoidal cone invariant systems [1].

JOINT POSITIONING AND RADIO CHANNEL ESTIMATION

Researchers: Bo Bernhardsson, Anders Mannesson

Funding: VR

The project works with algorithms to combine information from gyros, accelerometers and compass sensors with radio channel estimation and to determine the fundamental properties of such schemes. The hope is to enable two technology advancements:

- a new method for significantly reduced drift in low cost navigation systems
- improved radio channel estimation for moving terminals, suitable for MIMO systems

Initial research show promising result as presented in the licentiate thesis by Anders Mannesson and in this presentation.

The work is based on angle of arrival estimation using antenna arrays which is a well studied problem with many different algorithms resolving the individual rays impinging on the array. However, less attention has been given to so called virtual array antennas where moving receiver elements are used. By tracking the movement of the element, an array with properties similar to a stationary array with multiple elements is

formed. By combining the IMU and the radio channel information, a map of the local radio environment can be obtained.

Tightly coupled nonlinear state estimation algorithms between IMU signals and radio channel estimates are used to simultaneously estimate this map and obtain improved pose estimates.

The major challenge is to battle the drift in sensors and radio crystal oscillators. We work with both real-world measurements and simulations to evaluate performance. Initial experiments show promising results. There is a dramatic improvement by including radio channel information compared to using dead reckoning, especially for movements longer than 10 seconds.

Our future research now focuses on improving radio channel estimation and prediction by adding IMU information and using motion models.

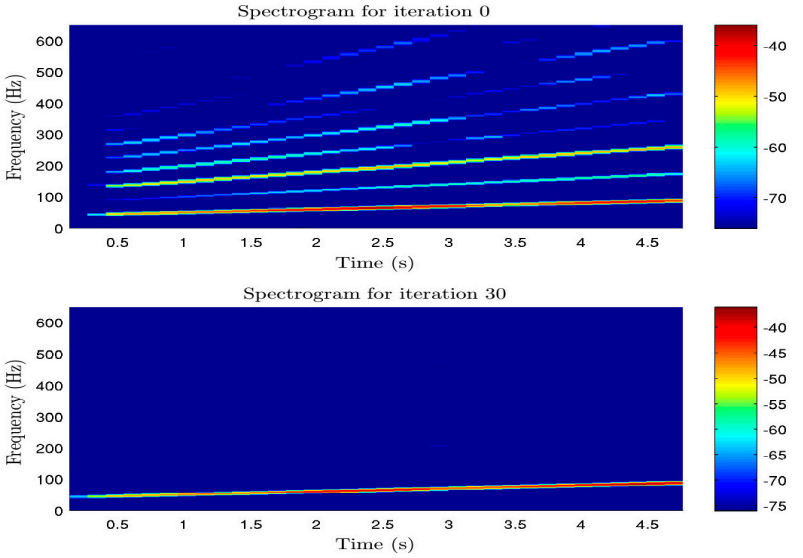
MARINE VIBRATOR CONTROL

Researchers: Bo Bernhardsson, Olof Sörnmo

Funding: PGS

The goal is to model and control large loudspeakers, so called marine vibrators, that are used to generate acoustic underwater signals. Performance requirements on out-of-band spectrum of the acoustic signal are achieved by careful characterisation of the dynamical behavior of the vibrators and use of frequency domain Iterative Learning Control (ILC). This has been found to successfully reduce the impact of nonlinearities such as friction and backlash. A 40 dB suppression of out-of-band harmonics has been acheived in experiments (in air).

The project is funded by the Norwegian company PGS.



CONTROL AND REAL-TIME COMPUTING

In the Control and Real-Time Computing area we work in two main directions:

- Implementation of control systems on resource-constrained implementation platforms, e.g., small embedded processors or networked controllers with limited communication bandwidth. This also includes event-based control.
- Applications of control to computing and communication systems. This includes control of server systems and adaptive resource management of embedded systems.

PERFORMANCE MODELLING AND CONTROL OF SERVER SYSTEMS

Researchers: Anders Robertsson, Karl-Erik Årzén, Karl Johan Åström and Björn Wittenmark in collaboration with Maria Kihl and Payam Amani at Dept of Electrical and Information Technology, LTH, Lund University

Funding: LCCC Linnaeus Center and VR

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 a rather unexplored area. Here, we believe the interaction of queuing theory and nonlinear control play a major role. The research is aimed at advancing the state of the art in control oriented modeling and control design of server systems by combining the scientific expertise from the telecommunication and the control communities. Important components in this research field are queuing theory, system identification, real-time systems and non-linear control theory. These fields have since long been well established research areas. However, the integration of this research with application to control of server systems gives raise to fundamental and challenging questions on how to e.g., combine and analyse discrete-event and continuous time flow models. The problems are of large theoretical as well as practical relevance in control of computing systems.

The main objectives of the research are:

- To use system identification and control theoretic methods to find good stochastic models and reliable state estimators for traffic and server systems
- Analyse the fundamental mechanisms in the combination of discrete-event based server systems and real-time control algorithms.
- To develop an experimental platform for experimental evaluation of control mechanisms.

EVENT-BASED CONTROL

Researchers: Anton Cervin, Bo Bernhardsson

Funding: VR and LCCC Linnaeus Center

The vast majority of all feedback controllers today are implemented using digital computers, relying on periodic sampling, computation, and actuation. For linear systems, sampled-data control theory provides powerful tools for direct digital design, while implementations of nonlinear control designs tend to rely on discretization combined with fast periodic sampling. In recent years, there has been a growing research interest in event-based control, in particular in connection to distributed and networked control systems. The basic idea is to communicate, compute, or control only when something significant has occurred in the system. The motivation for abandoning the time-triggered paradigm is to better cope with various constraints or bottlenecks in the system, such as sensors with limited resolution, limited communication or computation bandwidth, energy constraints, or constraints on the number of actuations.

INTEGRATED SCHEDULING AND SYNTHESIS OF NETWORKED EMBEDDED EVENT-BASED CONTROL SYSTEMS

Researchers: Anton Cervin, Karl-Erik Årzén, Yang Xu, Enrico Bini, in collaboration with the Embedded Systems Lab at Linköping University

Funding: ELLIIT and LCCC

Modern embedded control systems comprise periodic and sporadic software tasks that control several physical processes and execute on platforms with multiple computation and communication components. The project will focus on the complex system timing induced by resource sharing among the tasks, which is one of the main characterizations of the control quality. This control quality, which is affected negatively by long and varying computation and communication delays in the control loop, will be considered during system-level scheduling and optimization, as well as during controller synthesis by delay-compensation techniques.

Many control systems have time-varying resource demands, implying that scheduling policies and control strategies must be adapted at runtime to provide high control quality and efficient resource usage. Such variations are inherent in event-based control, which is an emerging technology in resource-constrained systems, but also occur depending on the states of the controlled processes or as a result of process disturbances and mode changes. The project will therefore also consider runtime optimization techniques to address such variations.

The project aims to push the state of the art of integrated control and computer systems design in several directions. We shall develop design methods for control-quality optimization of embedded control applications running on distributed execution platforms, which, for example, are very common in the automotive systems domain. Our subsequent aim is to develop design-time and runtime optimization methods that trade off control quality with the varying resource requirements present in multi-mode and event-based control systems. The long-term objective of the project is to develop an optimization and resource-management framework to be used for the design and implementation of future resource- constrained and adaptive embedded control systems.

LUCAS - LUND CENTER FOR APPLIED SOFTWARE RESEARCH

Researchers: Karl-Erik Årzén, Rolf Johansson, Anders Robertsson, Anton Cervin, Anders Blomdell, in collaboration with Dept of Computer Science, Lund University

The Center for Applied Software Research (LUCAS) is a collaboration between the software-oriented parts of the Departments of Automatic Control and Computer Science at LTH. 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.

LUCAS started in 1999 and its status has changed over the years. Currently its main role is to act as an umbrella organization. The main activity is the annual LUCAS workshop.

CLOUD CONTROL

Researchers: Karl-Erik Årzén, Bo Bernhardsson, Anders Robertsson, Anton Cervin, Anders Rantzer, Martina Maggio, Alessandro Papadopoulos, Manfred Dellkrantz, Jonas Dürango, in collaboration with Maria Kihl's group at the Dept of Electrical and Information Technology, Lund University and Erik Elmroth's group at Umeå University

Funding: VR

We take a control theoretic approach to a range of cloud management problems, aiming to transform today's static and energy consuming cloud data centers into self-managed, dynamic, and dependable infrastructures, constantly delivering expected quality of service with acceptable operation costs and carbon footprint for large-scale services with varying capacity demands. Such data centers will form the backbone of the digitalized society by providing unparalleled information storage and processing capabilities.

Today's explosive growth of the Internet and mobile connectivity hints at a digitized society where information is created, stored, processed, and distributed at a previously unparalleled rate, already today including, e.g., multimedia services as online TV and music, social networks, scientific applications, and business services such as e-commerce, online banking, enterprise applications, etc. Whereas the Internet is becoming ubiquitous and provides reasonably mature communication abilities, significant advancements are required to create the future cloud data centers that will form a backbone for information processing and storage, and thus be a key enabler of the digitized society.

However, with a continued extreme growth in capacity demands, today's cloud data center infrastructures are literally jeopardizing the continued development of the digitized society by simply being too static, providing too low Quality-of-Service (QoS), and by consuming ridiculous amounts of energy. Today's data center infrastructures are not even near being able to cope with the enormous and rapidly varying capacity demands that will be reality in a near future. So far, very little is understood about how to transform today's data centers (being large, power-hungry facilities, and operated through heroic efforts by numerous administrators) into a self-managed, dynamic, and dependable infrastructure, constantly delivering expected QoS with reasonable operation costs and acceptable carbon footprint for large-scale services with

sometimes dramatic variations in capacity demands.

To meet these challenges, the project addresses a set of fundamental and inter-twined auto-management challenges assuming that there during execution are stochastic variations in capacity needs and resource availability, as well as changes in system response and operation costs (in monetary and energy terms). The challenges include how much capacity to allocate at any time for an elastic application, where to allocate that capacity including optimizing complete data center energy efficiency, if to admit an elastic service with unknown lifetime and future capacity demands, as well as how holistic management can be performed to optimize the various management tools' concerted actions.

This cross-disciplinary project builds on a collaboration between Umeå University and Lund University with complementing expertise on cloud management and control of computing systems. The collaboration addresses fundamental algorithmic challenges that in industrial collaborations have been identified as crucial.

The project is funded by a 20 million SEK framework grant from the Swedish research council (VR).

FEEDBACK-BASED RESOURCE MANAGEMENT FOR EMBEDDED MULTICORE PLATFORMS

Researchers: Karl-Erik Årzén, Martina Maggio, Enrico Bini, Georgios Chasparis

Funding: VR

This project is aimed at advancing the state of the art in dynamic resource management for embedded multicore computing platforms by applying control theory. Efficient resources usage is becoming one of the most important design criteria for all types of computer systems from large data centers over laptops, cellular smart phones, and embedded computing devices down to sensor network nodes. The overall goal of the resource management can be to minimize power consumption or generated heat, or to have better means for differentiating applications against each other, e.g., ensure that a safety-critical application is guaranteed sufficient resources also in the presence of less important applications.

In embedded systems there are many resources that need to be managed, e.g.,memory, buses, and power. The most important resource, however, is the CPU. By controlling how much and where different applications may execute it is also possible to control the power consumption and the heat generation. Hence, the focus of this project is control of CPU resources.

VICYPHYSYS - VIRTUAL CYBER PHYSICAL SYSTEMS

Researchers: Enrico Bini, Karl-Erik Årzén

Funding: Marie Curie Actions—Intra-European Fellowships (IEF)

In Cyber-Physical Systems (CPS), a physical process is controlled by a pervasive network of embedded computers. In this environment, computation, communication, and the physical environment are so tightly coupled that process dynamics blends into the behavior of computation. A proper design of such systems requires understanding the joint dynamics of computers, software, networks, and physical processes. The project investigates the creation of a foundational theory and a design methodology for Cyber-Physical Systems.

POWER AND TEMPERATURE CONTROL FOR LARGE-SCALE COMPUTING INFRASTRUCTURES

Researcher: Martina Maggio

Funding: VR

Modern computing systems are constrained by dark silicon, the abundance of transistors enables processors to draw more power than they can safely sustain. For example, the Exynos 5 processor (in the Samsung Galaxy S4 phone) has a 5.5W peak power that is nearly twice the maximum sustainable heat dissipation, limiting peak speed to less than 1 second. At the other end of the spectrum, the next generation of exascale supercomputers is predicted to be constrained by an operating budget of approximately 20 MW. In addition, Microsoft was recently fined for not using enough power and violating an agreement with a utility company. Executing efficient code in these systems requires solving a constrained optimization problem: maintaining the power budget, while maximizing performance within the power constraint.

Many separate components contribute to total power consumption and various techniques have been proposed to manage individual components. For example, management systems exist for CPU allocation, dynamic voltage and frequency scaling, processor idling, cache, DRAM, and disk. However, the coordination of these many actuators is non-trivial and requires knowledge on all the potential nonlinearities that the hardware infrastructure may expose. The goal of this research is to develop a platform-independent resource manager to control the temperature and power consumption of large computing infrastructures like data centers. This management system should be general with respect to the running platform and must address three challenges:

- **Unknowns**: prior research approches rely on rigorous models for either the specific machine under control or for a specific application and platform. A generalized power management system, however, must either construct its models on the fly or compensate for inaccuracies and unknowns in the model.
- **Interaction**: System components interact to produce a complex (often nonlinear) effect on power, temperature and performance. If individual components are controlled separately, their interaction can lead to suboptimal behavior, even when these separate controllers are individually optimal. Thus, a generalized power management system must coordinate all available components even if they are not known at design time or vary at runtime.
- **Optimization**: A power manager must not exceed the power budget, yet must also deliver the best possible performance for a given budget. A generalized approach must not sacrifice too much performance for generality.

This research addresses the above challenges, the result so far has been a machine-level power management system that is general with respect to the components it manages, and uses feedback control to ensure that the power and temperature budget are respected, while delivering the best possible performance to the running applications. The project originated by a pubblication at PACT 2013 (Parallel Architectures and Compilation Techniques) entitled "ThermOS: System Support for Dynamic Thermal Management of Chip Multi-Processors". It has lead in 2014 to the publication of the article "PCP: A Generalized Approach to Optimizing Performance Under Power Constraints through Resource Management" at ICAC 2014 (International Conference on Autonomic Computing).

PROCESS CONTROL

The department has always had an active collaboration with the process industry as well as with the suppliers of process control instrumentation and systems. Most of the research projects are formed together with the process industry, and several of them are performed with active participation by staff from industry. Many of the research results are also transfered to instrument and system suppliers, and implemented and used in process industry.

Most of the process control research is today performed within the Process Industrial Center at Lund University, PICLU.

PROCESS INDUSTRIAL CENTRE AT LUND UNIVERSITY

Researchers: Olof Garpinger, Tore Hägglund, Martin Hast, Charlotta Johnsson, Ola Johnsson, Anna Lindholm, Vanessa Romero Segovia, Kristian Soltész

Funding: SSF

With support from the Swedish Foundation for Strategic Research (SSF), the process industrial centre PIC-LU has been established in collaboration with the department of Chemical Engineering.

The overall goal of PIC-LU is to establish, in cooperation with Swedish process industry, an internationally leading centre for research and professional training in process optimization and control.

In the research program, methodology and tools for modelling, optimization, and control of industrial processes are developed, in order to improve production systems with respect to flexibility, controllability, and availability. The methodology and the tools are developed from specific solutions to process control problems suggested by the industrial partners. The goal is to make the results from PIC-LU industrially relevant, not only for the participating industries, but on a wide scale in process operation and automation. The industrial partners are Borealis, K A Rasmussen, Modelon, Novo Nordisk, Novozymes, Perstorp, and Pfizer.

In the competence development program, the main goal is to increase the competence level of process optimization and control in industry as well as in academy. The goal will be reached in two ways; through an educational program at different levels for staff in process industry, and by directed efforts in MSc and PhD programs at the university.

PROCESS INDUSTRIAL CENTRE – OPTIMIZATION, PERFORMANCE, INTEGRATION AND CONTROL (PIC-OPIC)

Researchers: Charlotta Johnsson, Anna Lindholm and Tore Hägglund in cooperation with researchers from Dept of Chemical Engineering at Lund University as well as researchers at Linköping Univeristy

Funding: SSF

With support from the Swedish Foundation for Strategic Research (SSF), the PIC-opic project was established in 2012 in order to strengthen the integration between the various hierarchical control level found in companies today. Generally, the lower levels of the automation hierarchy are focused on operational decisions and thereby close to the real production and real time control

and measurements, whereas the higher levels are closer to strategic decisions and thereby closer to economical performance evaluations. PIC-opic is a joint research between Lund University and Linköping University. It consists of three (3) subprojects with the aim of integrating different levels in the hierarchy. Subproject A focuses on buffer management and inventories, subproject B focuses on key performance indicators and subproject C focuses on economical optimization. The three projects all incorporate knowledge and personnel from the two research centres PIC-LI and PIC-LU.

PID CONTROL

Researchers: Karl Johan Åström, Olof Garpinger, Tore Hägglund, Martin Hast, Vanessa Romero Segovia

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. It is also translated to Spanish 2009: "Control PID avanzado". The research is currently focused on the following topics:

Measurement noise filtering for PI and PID controllers

Measurement signals are always corrupted with noise.This will be reflected in the control signal behaviour in e.g. high variance or large inter-sample jumps if considering a discrete time setting. Previous work on PI and PID controllers often focus on proportional-, integral- and derivative gains at design but the filter action is added afterwords such that a reasonable sensitivity to noise is given. However, the filter changes phase and gain of the controller and the initial tuning may not give satisfying results.

In this project, we investigate the trade-offs between load disturbance attenuation, robustness and the undesired control activity generated by measurement noise. The goal is to find design rules that take all these aspects into account in the PID design, where the measurement noise filter is included.

A new methodology that uses a second order filter to attenuate the fluctuations of the control signal due to measurement noise, and which tuning parameter is given by the filter time constant T_f, has been derilved. The main contributions are:

- Filtering design criteria for attenuation of measurement noise, which include the Control Bandwidth, the Standard Deviation of the Control Signal (SDU), and the Noise Gain.
- An iterative method to calculate the filter time constant T_f based on the gain crossover frequency, which considers the trade-offs between performance, robustness, and measurement noise attenuation.
- Simple rules derived from the results obtained from the iterative method, which allow to find the filter time constant for common PID tuning rules based on FOTD models.
- Simple rules to find the added dynamics in the nominal FOTD model due to filter introduction, which leads to the recalculation of the controller parameters.

Software tools for design of PID controllers

A Matlab-based software tool for optimal PID design has been developed at the department. The software finds the PI or PID controller that minimizes the Integrated Absolute Error (IAE) value during a step load disturbance on the process input, with respect to robustness con-

straints on the sensitivity and complementary sensitivity functions. This PID design method is called SoftWare-based Optimal Robust Design (SWORD).

Varying the time constant of the low-pass filter, it is possible to find optimal or near-optimal solutions to an optimization problem extended with a noise sensitivity constraint. As the time constant of the low-pass filter increases, the PID controller will gradually transform into a PI controller and then finally an I controller. This gives a natural set of I, PI and PID controllers to choose from. The final controller can be selected based on visual feedback of the control signal activity due to measurement noise.

The optimal solutions to the extended optimization problem can also be used to compare the performance of PI and PID controllers to examine the benefit of the derivative part for different processes. Assuming continuous time white Gaussian noise with unit spectral density, it is possible to derive optimal PI and PID controllers with the same robustness and noise sensitivity constraints. The ratio of optimal PI performance divided by optimal PID performance for the case of medium noise sensitivity and high robustness. Each symbol represents a process in a batch of 134 models representative for the process industry. These have been classified with respect to their normalized time delay, τ. Processes with τ close to zero or one generally benefit less from the derivative part than processes in between. Two process types, however, benefit more from derivative action than others, namely those with two identical poles and little delay as well as second order processes with one integrating pole and little delay.

In order to use software-based optimal design methods like the one described, it is important to have better modeling tools than what is normally available in the process industry. A simple step response test have been shown insufficient to design PI and PID controllers that are close to optimal. Research have shown that process information around the phase -125° is sufficient to find first order time delayed models for optimal PI control. For optimal PID control the model needs to be accurate around a larger span of phase angles from -125° down to around -235°. With the right modeling tools it should then be fairly easy to incorporate optimal software tuning into a new generation of autotuners that will be far better than any existing PID tuning rules.

PID design by convex optimization

Convex optimization has grown to become a mature and powerful tool in a vast number of research fields. Design of PID controllers subject to robustness constraint is not a convex optimization problem, however, it fits well into the framework of the convex-concave procedure. Although globally optimal controllers cannot be guaranteed, the method produces robust controllers with good performance. The work is done in collaboration with Stephen Boyd, Stanford University.

Criteria and Trade-offs in PID Design

Control design is a rich problem which requires that many issues such as load disturbances and set-point tracking, model uncertainty, and measurement noise are taken into account. In this work we introduce trade-off plots for PI and PID controllers, which give insight into the design methods, criteria and design compromises.

Interactive 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.

AUTOMATIC TUNING

Researchers: Josefin Berner, Kristian Soltesz, Tore Hägglund, Karl Johan Åström

Methods for automatic tuning of PID controllers were developed in the early eighties, and implemented in industrial single-station controllers and DCS systems. A main reason was the technology shift from analog to computer-based controllers and systems at that time, which made implementation of such tuning functions possible. These methods were limited by the computer power and the knowledge about PID design that were available at that time. Since then, the computational power and the knowledge about PID design has increased, which provides the possibility to develop new tuning functions with better performance.

Within process industry, a large number of processes can be accurately modeled using simple models, i.e. SISO FOTD or SOTD, and there are efficient tuning rules for PID controllers that are based on these model structures.

We aim at developing a methodology for automatic tuning of PID controllers, using nonlinear feedback for idenfication input generation and optimization based methods for both process parameter identification and controller synthesis.

The main components of the auto-tuning alogorithm are the following:

1. Generate identification input with little or none a priori system information
2. Transfer function parameter identification through optimization
3. Model verification
4. PID synthesis
5. Performance evaluation

As a case study, a modified version of the method has been applied in closed-loop controlled anesthesia.

Another approach for automatic tuning is to conduct a simple experiment, using an asymmetric relay function as feedback. From the experiment the static gain and the normalized time delay of the system can be estimated, and from this a FOTD model can be achieved from analytical formulas. The experiment data can also be used to find a higher order model using numerical parameter estimation methods. From the achieved model the parameters of a PI or PID controller can be tuned either by existing tuning rules or by optimization methods.

This autotuner is currently under development and will hopefully be tried out on some applications in an energy management system for buildings during the spring.

HIERARCHICAL SCHEDULING AND UTILITY DISTURBANCE MANAGEMENT

Researchers: Anna Lindholm, Charlotta Johnsson

The research is part of the Process Industry Centre (PIC), and is performed in collaboration with Perstorp AB and researchers from the Department of Mathematics and the Department of Management and Engineering at Linköping University.

The chemical industry has during the past decades become a global marketplace with strong competition between manufacturers, which requires a more agile plant operation to increase flexibility and decrease production costs. Planning, scheduling, and control are some key features that have large economic impact on process industry operations. In this research project, a hierarchical approach to integrate scheduling (on a timescale of days) with production control (on a timescale of hours) is suggested. The approach focuses on sites with several interconnected production areas with continuous production The scheduling level is denoted production scheduling (PS) and the production control level detailed production scheduling (DPS), in agreement with the ISA-95 terminology. The production scheduling takes orders, forecasted orders, and the actual production per day as inputs to make a production schedule for a month ahead divided into daily time periods. The objective of the production scheduling is to make a production schedule that serves as an input to the lower level in the hierarchy, the detailed production scheduling. The production schedule is updated every day in receding horizon. The objective of the detailed production scheduling is to handle daily disturbances at the site in order to minimize the economical influence of these disturbances. Reference values for the sales of products are given by the production schedule, and predicted disturbance trajectories are also given as input for the detailed production scheduling. The detailed production schedule has a timescale of hours and is updated every hour in receding horizon.

The focus for the detailed production scheduling is currently disturbances in the supply of utilities, such as steam and cooling water. Utilities are often shared between the production areas at a site, and management of these disturbances thus becomes an interesting topic when production areas are also connected by the flow of products. A generic method for minimizing the effects of disturbances in utilities has been developed, which requires a model of the site. Different modeling approaches have been suggested and the objective has been to start with simple and quickly obtained models,

Perstorp site at Stenungsund

and step by step move towards more elaborate models. The current model for utilities assumes a linear relation between the supply of a utility to an area and the production in the area.

The research is conducted in close collaboration with process industrial companies, in particular with Perstorp, that is a world leader within several sectors of the specialty chemicals market.

DECENTRALIZED CONTROL STRUCTURES

Researchers: Martin Hast, Tore Hägglund

There is an unfortunate gap between the centralized computational approaches of multivariable 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. 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.

Low-order Feedforward Controllers

Feedforward is a powerful method to improve the performance of feedback loops. Feedforward can be made both from setpoint and measurable load disturbances. In this project, the goal is to improve both structures and design methods for feedforward control from load disturbances.

The basic idea for design of feedforward compensators is simple. The ideal compensator is formed as the dynamics between the load disturbance and the process output, divided by the dynamics between the control signal and the process output, with reversed sign. However this ideal compensator is seldom realizable. Therefore, there is a need for design methods. There are surprisingly few such methods presented in the literature, and the methods do normally not take the feedback control into account in the design.

In a first phase, new simple tuning rules for feedforward compensators have been derived. The design objective is to minimize IAE without getting any overshoot in step load disturbance responses. This work has been done in collaboration with University of Almeria. This collaboration continues, and University of Brescia has also been involved in the project where e.g. performance indices for feedforward control have been developed.

Using a structure that decouples feedback and feedforward action, optimal design rules that minimizes ISE has been developed. The used structure simplifies tuning of the feedforward controller by allowing the controller to be tuned with respect to the open-loop system while maintaining its properties and performance when used in a closed-loop setting. The structure also enables independent re-tuning of both the feedback and the feedforward controller. Work has also been done concerning characterization of optimal low-order feedforward controllers and practical considerations for implementation.

PID controllers is often implemented with set-point weighting to improve the response to changes in the reference. By using convex optimization techniques the parameters for the set-point weights can be found efficiently, fast as well as be guaranteed to be globally optimal. By solving an optimization problem to find the optimal set-point weights for a large batch of processes, tuning rules have been found that minimizes IAE. The same optimization framework and formulations can also been used to tune feedforward controllers from measurable disturbances.

OPTIMIZING FERMENTATION CONTROL FOR *B. LICHENIFORMIS*

Researchers: Ola Johnsson, Charlotta Johnsson, Tore Hägglund

This project is performed in collaboration with Novozymes A/S and Dept of Chemical Engineering, Lund University within the PICLU centre.

The project will focus on developing, improving and optimizing fermentation control strategies for the *B. licheniformis* fed batch processes. This process can produce vast amounts of protein but is sensitive to overdosing and process disturbances which lead to process variations and possibly crashed fermentations. There is thus a strong motivation for developing more robust control strategies for this process. The project aim is to develop a general method for finding optimal control strategies for various *B. licheniformis* production strains.

As part of this project, a general control strategy for control of bacterial growth in fed-batch processes has been developed and tested in pilot scale. Currently, the project is focused on implementing this control strategy in production scale for trials in industry. Several pre-studies have been performed to verify that the strategy can be successfully applied for control of real industrial processes.

IN-VEG

Researcher: Charlotta Johnsson in cooperation with researchers from Dept of Food Technology, Engineering and Nutrition, Lund University

Funding: Vinnova

The In-Veg research project (Innovative production systems for more attractive vegetablebased products) is run by Department of Food Engineering, Technology and Nutrition and contains a collaboration project with Department of Automatic Control. The aim of the project is to strengthen Swedish SMEs capacity for innovation and cost efficiency in product development and production of food from fruits and vegetables.

The project contains four subprojects with interdisciplinary research. Automatic Control is mainly involved in the first of the four projects;

- School meal potato for the future - quality throughout the value chain
- Locally produced and processed onions
- Use of waste and by-products from leek
- Added-value through fermentation - new products and processes

ROBOTICS

ROBOTICS RESEARCH

Researchers: Rolf Johansson, Anders Robertsson, Martin Karlsson, Andreas Stolt, Olof Sörnmo, Björn Olofsson, Karl Berntorp, Karl-Erik Årzén, Mahdi Ghazaei, Fredrik Bagge Carlson, Anders Blomdell, Anders Nilsson, Martin Holmstrand, Jang Ho Cho, Pål Johan From, in close cooperation with colleagues from neighbor departments at the Robotics lab at LTH, Lund University, and ABB Robotics, Västerås, Sweden

Robotics offers both theoretical and practical challenges. Robotics is a multi-disciplinary topic and we collaborate with both national and international robotics colleagues regarding different aspects of robotics and we also have a close cooperation with industrial partners. Our main research are in motion and compliance control, control system architectures and different sensor fusion problems with application mainly to industrial manipulators. We use mainly modified and extended ABB robot control systems as experimental platforms.

The laboratory for robotics and real-time systems is centered around industrial manipulators with open control system architectures. In the lab we have several generations of robots from an elderly ABB IRB6 robot, an ABB IRB2000 robot, an ABB Irb2400 (S4CPlus) to the more modern ABB IRB140 (IRC5), Gantry-Tau robot (IRC5), ABB IRB120 (IRC5) and the latest dual-arm concept robot Frida (ABB IRC5). Hardware interfaces have been developed to create an open system suitable for control experiments (Orca/Orcinus). The computer hardware is either PCI-based with both microprocessors and signal processors integrated into an embedded system for hard realtime control in one of the labs and integrated with an additional PCI-based G4 PowerPC for the new Open Control system based on S4CPlus and the newly developed networked architecture running on Linux/Xenomai-platforms.

The systems are connected to a network with workstations, which are used for program development and control design. A purpose of the current project is to show how to organize open robot control systems and to verify these ideas by means of experiments.

One goal is to permit efficient specification and generation of fast robot motions along a geometric path which requires coordinated adjustment of the individual joint motions. Another aspect of robot motion control is how to to integrate simultaneous control of force and position according to ideas of impedance control in which stability is an important theoretical issue. A major topic in this project is to integrate aspects of control, sensor fusion and application demands using robot vision and force sensing. Another project is on the structure and programming of control systems for industrial robots. The problem addressed is how the software architecture and the realtime structure of a robot control system should be designed to allow easy and flexible incorporation of additional sensors and new control algorithms.

A software layer between a supervisory sequence control layer and the basic control level has been proposed. Case studies and prototype experiments show promising results and further implementation is going on. The project Autofett aimed towards use of force control in manufacturing operations such as robotized fettling and is now continued in the SMErobot and FlexAA-projects. New sensor interfaces with modification of hardware and realtime software architectures have been developed to accommodate the use of force control algorithms based on workspace sensing.

ROBOTICS LAB

Several research interests are represented in Robotics Lab:

- Open Control Software Architectures
- Exteroceptive Robots
- Force Control
- Robot Vision
- Sensor Fusion
- Adaptive and Iterative Learning Control
- Task-level Programming

Robot control systems and other manufacturing equipment are traditionally closed. This circumstance has hampered system integration of manipulators, sensors and other equipment. As a result, such system integration has often been made at an unsuitably high hierarchical level.

The purpose of past and present projects is to show how to organize open robot control systems and to verify these ideas by means of experimental verification.

As a part of this research, we have developed several experimental open robot control systems. The systems are built around industrially available robots that have been reconfigured for experimental purposes.

The developed specific robot interfaces and the integration of the robots into a complete system forms a unique environment for testing and development of algorithms for improvement of performance, sensor integration, programming automation and autonomous operation.

ENGROSS - ENABLING GROWING SOFTWARE SYSTEMS

Researchers: Karl Berntorp, Anders Robertsson, Karl-Erik Årzén, in collaboration with the Dept of Computer Science and the Dept of Mathematics, Lund University

Funding: SSF

The ENGROSS project is an SSF framework project on software-intensive systems. This project is focused on the central problems of complex software systems; how such systems can be built in order to be more flexible, robust and possible to compose at the same time. The project is structured in three layers:

- Systems Research
- Demonstrator
- Disciplinary Research

The systems research is based on previous work at Department of Computer Science in the form of the Palcom middleware for loosely interconnected systems. In ENGROSS Palcom is extended to support real-time applications and safety-critical applications.

The main demonstrator in ENGROSS is a grocery-store mobile service robot and surrounding IT systems, sensing, and communication. The primary task for a grocery robot is to put arriving items on shelves in the shop. The robot demonstrator gives rise to many situations where systems need to be integrated in new ways. The current version of the demonstrator is based on the Frida two-armed robot from ABB and a mobile service robot platform from the Fraunhofer Institute for Manufacturing Engineering And Automation (IPA).

The robot demonstrator also serves as a platform for the disciplinary research in the project:

- Mobile manipulation
- Vision
- Localization and navigation
- Resource-constrained embedded systems
- Safety

INROSY—INTELLIGENT NETWORKED ROBOTICS SYSTEMS WITH RECONFIGURABLE EXOGENOUS SYSTEM SENSING

Researchers: Klas Nilsson, Dept Computer Science, Rolf Johansson, Anders Robertsson, in cooperation with Prof. Il Hong Suh, Hanyang University, Seoul, Korea.

Funding: STINT

Nowadays, we are living with automation systems that have intelligence such as cleaning robot, human care robot and guiding robot within everyday life. These robots will be key components of our daily life. It is true that quality of our life can be improved by these robots. Unlike the industrial robots that continuously repeat their given jobs in a fixed environment, service robots have to provide event-driven services, while keeping natural human-robot interaction in dynamic changing environment. Therefore, intelligence including sensory-motor coordination is thought as a core element of everyday life robot. The intelligence of a robot depends on the cognitive ability for environment, and how the robot acts properly with cognitive results.

In this project, we address research issues on software architectures for reactive, cognitive behavior in robotics work spaces.

PRACE – THE PRODUCTIVE ROBOT APPRENTICE

Researchers: Rolf Johansson, Anders Robertsson, Mahdi Ghazaei

Funding: European Union FP7, under the programme PRACE

The objective of PRACE is the development of a highly adaptable two handed, mobile robot system for automation of typical small batch assembly operations. An important key feature is the fast and intuitive training of the PRACE system.

Driven by the trend to a more and more customer specific production the boundary conditions for assembly automation have changed significantly. As the systems available on the market cannot cover this extreme flexibility towards weekly changing applications a new robot system concept will be developed within PRACE. An important requirement is the ability to train the robot system with worker skill fast and intuitive.

The PRACE concept basically relies on robot learning by demonstration. We compare the robot learning to a master-apprentice-relationship. There, a master teaches an apprentice by instructing certain skills by demonstration. The apprentice watches the actions and effects to categorize this newly gathered knowledge into his knowledge base. Then, while applying this new skill, the master corrects the execution by refining the experience. This loop is iterated until the master is satisfied with the result.

Another important aspect of the PRACE robot system is the operation without safeguards to reach the target of fast setup times. Operation without safeguards however limits the maximum robot velocity. To remain competitive with the human worker a dual-armed robot approach is followed to reach a similar working output as the human worker by modest robot velocities.

With the combination of dual-armed manipulation and a mobile platform to provide local mobility within the working place basically new application tasks may be now automated economically by this new system approach. Using a

modular approach the PRACE system can even be recombined to use only parts of the robot system for dedicated applications, i.e. using only a single arm or using the system without mobility.

Different assembly use cases are defined as test environment of the PRACE concept. At end of the project an evaluation phase in real production environment is planned to test the functionality of the system and to ensure the ability to train the system by non-expert users within half a day.

SMEROBOTICS

Researchers: Rolf Johansson, Anders Robertsson, Björn Olofsson, Olof Sörnmo

Funding: European Union FP7, under the programme SMErobotics

Over two-thirds of European workers in manufacturing are employed in small and medium-sized enterprises (SMEs). Their primary means of competition is to respond rapidly to changing production needs and to keep product quality at a very high level.

While robots are able to carry out repetitive tasks to a high standard, they do not meet the demands of SMEs for high flexibility. Today's robots know only their nominal task, which limits their ability to deal with frequent changes in the manufacturing process.

For the operation of robots in an SME environment, which is typically less structured and involves more uncertainties than large-scale or mass-production industries, the currently available solutions result in overly complex system integration.

Instead, cognitive abilities should be included in the equipment and cognition should take place in both the robot and the human, such that the worker's knowledge can be fully utilised and productivity demands can be met. Additionally, the concepts and symbols used in dialogues need to have a common grounding in order to guarantee ease of use.

Therefore, we propose the SMErobotics work system, which covers all phases of the robot lifecycle and in which humans and robots can together deal with SME manufacturing uncertainties and are symbiotically able to learn from each other and to learn from the past handling of uncertainties. The SMErobotics vision is to deploy such robots on SME shop floors, with the benefit of long-term improvements in productivity.

The SMErobotics initiative pays careful attention to SME-related issues and scientific challenges, as is reflected by its strong industrial involvement supported by leading researchers and building on successful collaboration between industry and academia as well as on demonstration-driven research from the SMErobot project.

Additional partners will be included in order to widen the initiative's impact by transferring project results to European pilot applications of SME-compatible cognitive robot systems.

FLEXIFAB

Researchers: Rolf Johansson, Anders Robertsson, Fredrik Bagge Carlson, Martin Holmstrand

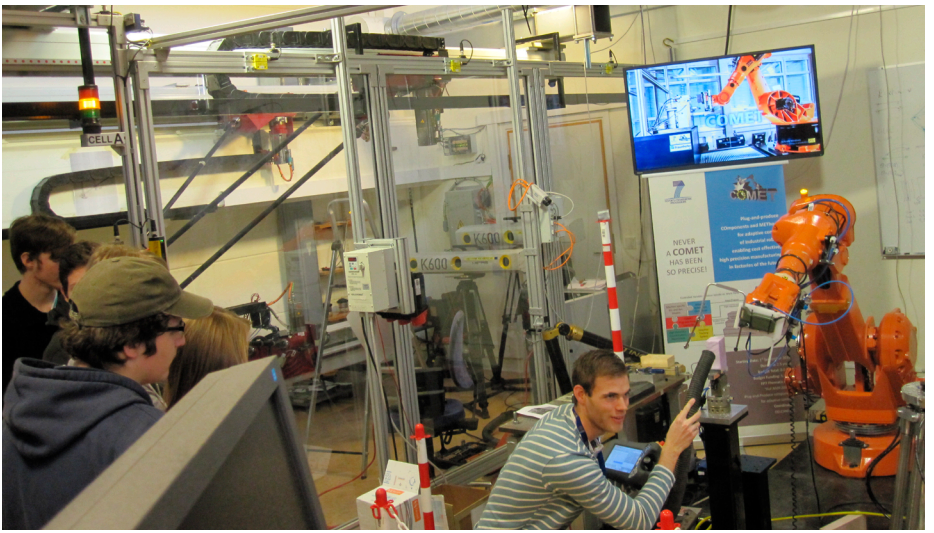
The FlexiFab system will provide the following key competitive advantages to the European welding Industry

- Enable European fabricators, metal-workers and welding companies to effectively compete in the growing use of aluminum alloys in the light-weight transport sector.
- Capitalising on the increasing pressure to replace traditional iron and steel material with aluminum alloys to reduce weight and thus fuel consumption of vehicles, trains, ships/boats and aeroplanes.
- Reduce the costs associated with the fabrication of aluminum structures, especially focused on components used within the transport sectors.

RobotLab@Lund will mainly work on the sensor integration, logging for weld status for automated quality assurance and control system of industrial robots for the frictions stir welding process.

The system will use friction stir welding technology (FSW), invented by one of the project partners, TWI, in the beginnining of the 1990s. The welding method offers a number of benefits for aluminum joining/welding such as:

- Excellent weld mechanical properties.
- A mechanised repeatable process.
- No special pre-weld edge profiling or cleaning required.
- No shielding gas required.
- Low distortion and shrinkage due to solid-state nature of welding process.
- Welding in any position.
- High efficiency processing with very low energy consumption.
- Ability to weld the 'non-weldable' aluminium alloys such as the 2000 and 7000 series
- Operator Health & Safety benefits:
  1. No harmful welding fumes or hot metal spatter
  2. No UV radiation hazards.



AUTOMOTIVE SYSTEMS

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

KCFP, CLOSED-LOOP COMBUSTION CONTROL

Researchers: Rolf Johansson, Gabriel Ingesson in cooperation with Lianhao Yin, Assoc. Prof. Per Tunestål and Prof. Bengt Johansson, Div. Combustion Engines, Lund University

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

Project aims:

- Reducing emissions, improving efficiency and repeatability of HCCI and partially premixed combustion (PPC) using closed-loop control;
- Control-oriented modeling and simulation of combustion processes;
- Model-based control and optimization evaluated on test beds.

Within the project a cycle-resolved physics-based HCCI model has been developed. The model includes a low-complexity model of the cylinder wall temperature dynamics in order to capture the relevant time-scales of transient HCCI when only small amounts of hot residuals are trapped in the cylinder. The temperature evolution of the gas charge is modeled as isentropic compression and expansion with three heat transfer events during each cycle.

Model predictive controllers based on linearizations of the model have been designed and evaluated experimentally. The considered control signals were the inlet valve closing and the intake temperature. The control performance was evaluated in terms of response time to set-point changes and the resulting output variance. The benefits of using hybrid models comprised of several linearizations of a nonlinear model have also been investigated.

During 2011, a continuous-time model of partially premixed combustion was developed and implemented in the Modelica language. The JModelica.org framework was used to formulate optimization problems on the resulting model. One use of this possibility is automatic calibration of the model parameters.

PREDICTIVE CONTROL AND SYSTEM OPTIMISATION OF WHEEL LOADERS

Researchers: Anton Cervin, in cooperation with Bobbie Frank and Mats Alaküla, Dept Industrial Electrical Engineering and Automation, Lund University, Anders Fröberg, Volvo Construction Equipment

Funding: Energimyndigheten

The today evaluating a hybrid drivetrain concept for contruction machine applications is a time consuming process. This is true as the control strategy needs to be developed by hand and tuned for the concept and each new sizing of the components and eventually optimized such that the concept can be compared with other concepts at its best.

The result is that too few concepts are studied and strategic decisions on drivetrain types is most suitable per machine / region / application / customer type and in overall are stalled due to

insufficient decision material.

The project at hand implements tools for comparing concepts in a fast manner where the control strategy is generated during concept optimisation. The same control strategy is input to online control performed in the prototype machine used for validation of the results within the project.

The goal in the project is to make the transition from the generated control code to implementation in machine with real-time constraints as smooth as possible. Actual concept comparison is carried out in the project and will be used as decision material for which future drivetrain layout to use for wheel loaders of different sizes.

The project also results in competence development at Lund University and that the Volvo CE industrial student reaches a licentiate degree.

BIOMEDICAL PROJECTS

ANESTHESIA IN CLOSED LOOP

Researchers: Tore Hägglund, Kristian Soltesz, in collaboration with professor Guy Dumont and the ECEM group, University of British Columbia, Vancouver, Canada

Funding: LCCC

After being an LCCC seedproject, the research became part of the department's biomedical projects and the results published in a PhD thesis. The objective is to develop an automatic control system for anesthesia.

Computer controlled, or automatic, drug delivery is the process of administering a therapeutic regime to a patient with computer assistance for calculation of optimal dose and delivery schedules. Computer control can improve drug therapy by reducing drug usage and costs, by permitting health care staff to work more efficiently and to provide better standard of care, by allowing the safe use of drugs that are difficult to administer, and by compensation for human failings with computer strengths, such as unlimited attention span and patience, and capacity for quick, accurate and redundant calculation.

Our goal is to develop an automatic control system for anesthesia and to demonstrate its efficacy, safety and benefits in an operating room. Although closed-loop anesthesia has previously been proposed and tested, it has yet to have a significant impact on clinical practice. Recent developments in sensing for anesthesia have opened new possibilities for closing the loop. Our research will focus on the deployment of new sensors optimized for controlled drug delivery, robust control methodology and extensive clinical validation.

Clinical partner in the project is the Department of Anesthesia at the British Columbia Children's Hospital (BCCH), Vancouver, Canada, where patient modeling data is collected and clinical trials of the control system are conducted.

A PID controller based drug delivery system for depth of hypnosis control was evaluated in a patient study (BCCH REB approval H10-01174) during 2011.

Our current aim is to extend the system to control hypnosis and analgesia simultaneously, by adding a second drug.

DIADVISOR™-PERSONAL MOBILE SHORT-TERM BLOOD GLUCOSE PREDICTOR AND TREATMENT ADVISOR

Researchers: Marzia Cescon, Fredrik Ståhl, Meike Stemmann, Rolf Johansson, Dawn Tilbury
Partners: Novo Nordisk A/S, Bagsværd, Denmark; Johannes Kepler University, Linz, Austria; Lunds University, Lund, Sweden; University of Padova, Padova, Itlay; Centre Hospitalier Universitaire de Montpellier, Montpellier, France; Toumaz Technology Ltd, Abingdon, UK; Sensor Technology and Devices Ltd, Belfast, UK; Ondalys, Montpellier, France; RomSoft, Iasi, Romania; Institute for Clinical and Experimental Medicine , Prague, Czech Republic; RICAM, Linz, Austria; Ramboll, Virum, Denmark; Federation Internationale du Diabete Region Europe, Brussels, Belgium

Funding: European Commision FP7

Diabetes Mellitus is a chronic disease of disordered glucose metabolism due to defects in either insulin secretion from the pancreatic beta-cells or insulin action. Type-1 diabetes (T1DM),

also called insulin-dependent diabetes mellitus (IDDM) is characterized by no production of insulin what so ever, whereas type-2 diabetes is caused by decreased sensitivity of the tissues to the metabolic effect of insulin. The basic effect of insulin lack or insulin resistance is to prevent the efficient uptake and utilization of glucose by most cells of the body, resulting in abnormally high blood sugar levels (hyperglycemia). Sustained hyperglycemia is associated with acute ketoacidosis, nephropaty, rethinopaty,neuropathy and damages to the cardio-vascular system, therefore intensive insulin therapy aiming at near-normoglycemia (80-100 mg/dL) has been strongly promoted during the last decade, following the results of the major Diabetes Control and ComplicationsTrial (DCCT) and follow-up Epidemiology of Diabetes Interventions and Complications (EDIC) studies. Focusing on tight blood glucose targets, the strategy comprises test of blood glucose levels at least four times a day, taking insulin at least three times a day by injections or using a pump and patient assistance by healthcare team through visits and phone calls. Meanwhile, the lack of improved quality of life and above all, the occurence of induced hypoglycemic events which may result in seizure, coma and eventually death preclude the feasibility of such a DCCT-like intensive therapy.

The problem of maintaining glucose levels within a predefined range by acting on insulin delivery is a control poblem, whose controlled variable is glucose utilization, measured output is either the subcutaneous glucose provided by the CGMS or the capillary glucose provided by the fingerprick, control input is the insulin intake, and the clinical criterion for success is plasma glucose. The system is subject to disturbances, the most important one being the meals. Control strategies involving the regulation of blood glucose levels in type 1 diabetes subjects range from classic PID feedback controller, run-to-run strategies to MPC algorithms.

The DIAdvisor™ project:
The DIAdvisor™is a large-scale integrating project (IP) aiming at the development of a prediction based tool which uses past and easily available information to optimise the therapy of type 1 and developed type 2 diabetes. The DIAdvisor™ is not dependent on specific sensor technologies and can be adapted to technologies like standard strip sensing, minimally-invasive continuous glucose sensors and emerging non-invasive methods.

For safety reason, the DIAdvisor™ system will be able to self-assess the confidence of its proposed decisions. For safety reasons as well as for the sake of therapy improvements, the system connects and provides information and trends to the Health Care Provider.

Glucose prediction is difficult and requires advanced science within the fields of physiological modelling, identification theory, control theory, medical device technology, risk management theory, sensor science and user understanding. It can be achieved only by a well balanced group of eminent experts, including academics, clinicians, user representatives and leading companies.

The expected impact of DIAdvisor™ will be improved diabetes control and quality of life in large populations of insulin treated patients, leading to fewer diabetic complications and lower Health Care costs. Moreover, the project will constitute a valuable opportunity for European companies to build up a special know-how leading to products that profoundly and positively have an impact on the lives of millions of people with other indications than diabetes.

TOOLS

Downloadable software developed at the department

JGRAFCHART

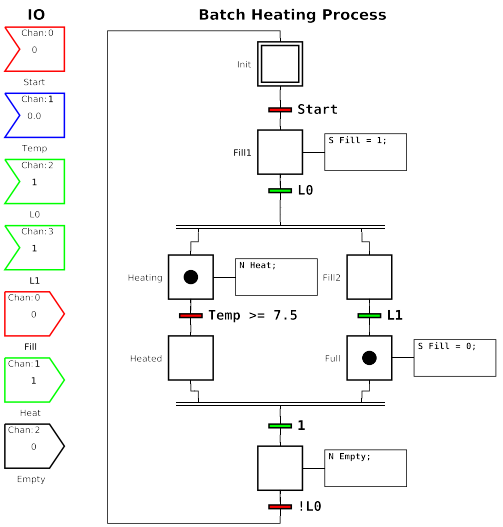
Grafchart is a language for supervisory level sequence control and procedure handling that has been developed at the department since 1991. Grafchart is based on ideas from Grafcet/Sequential Function Charts, Petri nets, Statecharts, and object-oriented programming.

The original implementation of Grafchart had the same name and was developed in G2 from Gensym Corporation. Using this platform Grafchart was used for batch recipe control, diagnosis of mode-changning processes, alarm filtering, implementation of operator decision support systems, and implementation of robot cells.

In 2001 an open implementation of Grafchart was made in Java. It is called JGrafchart and is used in our laboratory exercises on logical sequence control and batch control as well as in several research projects, for example, Grafchart for Industrial Automation and PRACE. It has also been used within the EU/GROWTH project CHEM for control in process industry, the EU FR7 project ROSETTA for robotic assembly, and several master's theses for example for modeling or code generation. DFKI has used it to implement the coordination of several demonstrators with real industrial equipment. Finally, there are a few cases where it is used for live industrial control, for example, myvision MANUFACTO.

JGrafchart is available for download as freeware.

During 2014, integrated support for LabComm and OPC UA has been added, socket I/O has been improved, a control library with a PID controller and an interactive education module has been added, and JGrafchart has been split into separate modules for editing, compilation, and execution. There have been five public releases of JGrafchart, for more details see the release notes.



Control of a Batch Heating Process implemented in JGrafchart.

JITTERBUG: A MATLAB TOOLBOX FOR REAL-TIME CONTROL PERFORMANCE ANALYSIS

JITTERBUG is a MATLAB-based toolbox that allows the computation of a quadratic performance criterion for a linear control system under various timing conditions. Using the toolbox, one can easily and quickly assert how sensitive a control system is to delay, jitter, lost samples, etc., without resorting to simulation. The tool is quite general and can also be used to investigate jitter-compensating controllers, a periodic controllers, and multi-rate controllers. As an additional feature, it is also possible to compute the spectral density of the signals in the control system. The main contribution of the toolbox, which is built on well-known theory (LQG theory and jump linear systems), is to make it easy to apply this type of stochastic analysis to a wide range of problems.

JMODELICA.ORG

JModelica.org is an extensible Modelica-based open source platform for optimization, simulation and analysis of complex dynamic systems. The main objective of the project is to create an industrially viable open source platform for optimization of Modelica models, while offering a flexible platform serving as a virtual lab for algorithm development and research. As such, JModelica.org provides a platform for technology transfer where industrially relevant problems can inspire new research and where state of the art algorithms can be propagated from academia into industrial use. JModelica.org is a result of research at the Department of Automatic Control, Lund University, and is now maintained and developed by Modelon AB in collaboration with academia.

MPCTOOLS

MPCtools is a freely available Matlab/Simulink-based toolbox for simulation of MPC controllers. MPCtools provides easy to use functions to create and simulate basic MPC controllers based on linear state space models.

The key features of the toolbox include:

- Support for linear state space models for prediction
- Quadratic cost function
- Linear inequality constraints on states and controls
- Observer support for state and disturbance estimation
- Integral action by means of disturbance estimation
- Two different QP solvers for solving the optimization problem

TRUETIME: SIMULATION OF NETWORKED AND EMBEDDED CONTROL SYSTEMS

TrueTime is a Matlab/Simulink-based simulator for real-time control systems. TrueTime facilitates co-simulation of controller task execution in real-time kernels, network transmissions, and continuous plant dynamics.

Features of the simulator include:

- Written in C++ MEX, event-based simulation
- External interrupts
- Possibility to write tasks as M-files or C++ functions. It is also possible to call Simulink block diagrams from within the code functions
- Network block (Ethernet, CAN, TDMA, FDMA, Round Robin, Switched Ethernet, FlexRay and PROFINET)
- Wireless network block (802.11b WLAN and 802.15.4 ZigBee)
- Battery-powered devices, Dynamic Voltage Scaling, and local clocks
- Stand-alone network interface blocks

From June 2010 the network parts of TrueTime are also available for Modelica using the Dymola 7.4 simulation tool from Dassault Systemes.

External Contacts

External contacts during 2014 both academic and industrial

Together with external contacts and partners the goal is to solve real control problems. A mix of fundamental and applied work is a cornerstone of our activities. In these kind of 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.

ACADEMIC CONTACTS

We have very good and fruitful relations and cooperations with a number of universities and academic institutions throughout the world. This year we have had important contacts with;

- Aalborg University, USA
- California Institute of Technology, USA
- Centre Hospitalier Universitaire de Montpellier, Montpellier, France
- DFKI, Smart Factory, Kaiserslautern, Germany.
- École Polytechnique de Montréal, Department of Computer Engineering, Canada
- Fraunhofer IPA, Stuttgart, Germany,
- Gifu University, Dept. Mechanical Engineering, Gifu, Japan
- Hanyang University, Seoul, Korea
- Istituto Italiano di Tecnologia (IIT), Genua, Italy
- Johannes Kepler University, Institute for Design and Control of Mechatronical Systems, Linz, Austria
- Korea Institute of Machinery & Materials (KIMM), Korea
- Kyushu Institute of Technology, Japan
- Linköping University, Dept. of Management and Engineering, Sweden
- LU Leuven, Belgium
- Lund University, Dept of Computer Science, Sweden
- Lund University, Dept of Electrical and Information Technology, Sweden
- Lund University, Dept of Heat and Power Engineering, Div. Combustion Engines, Sweden
- Lund University, Dept of Chemical Engineering, Sweden
- Massachusetts Institute of Technology, USA
- Norwegian University of Life Sciences, Dept of Mathematical Sciences and Technology, Ås, Norway.
- Norwegian University of Science and Technology (NTNU), Dept of Engineering Cybernetics, Norway
- Pasteur Institute, Functional Genetics of Infectous Diseases Unit, Paris, France.
- Pasteur Institute, Human Evolutionary Genetics group, Paris, France
- Politecnico di Milano, Dipartimento di Elettronica, Informazione e Bioingegneria, Milano, Italy
- Rensselaer Polytechnic Institute, USA
- Singapore Institute of Manufacturing Technology (SIMTech), A*STAR, Singapore

- Stanford University, Dept of Mechanical Engineering, Palo Alto, CA, USA
- Technical University of Denmark, Denmark
- Technion-IIT, Haifa, Israel
- Umeå University, Dept of Applied Physics and Electronics, Sweden
- Umeå Universitet, Dept of Computing Science, Sweden
- UNED, Spain
- Universidad de Almeria, Spain
- University of Brescia, Italy
- University of California, Center for Entrepreneurship and Technology, Fung Institute, Berkeley, USA
- University of Chicago, Dept of Computer Science, USA
- University of Florida, USA
- University of Jaén, Group of Robotics, Automation and Computer Vision, Jaén, Spain
- University of Padova, Dept of Clinical and Experimental Medicine, Padova, Italy
- University of Sydney, USA
- University of Wisconsin, USA
- Universität Paderborn, Germany
- Universität Stuttgart, Institute of Software Technology, Germany
- Zheijang University, Control Science and Engineering, Hangzhou, China

INDUSTRIAL CONTACTS

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

- 3E, Belgium
- ABB Corporate Research, Västerås, Sweden
- ABB Robotics, Västerås, Sweden
- Modelon AB, Sweden
- Novozymes A/S, Denmark
- Perstorp AB, Sweden
- PGS, Oslo, Norway
- SAAB AB, Linköping, Sweden
- SAAB Bofors Dynamics, Linköping, Sweden
- Schneider Electric Buildings AB, Malmö, Sweden
- Volvo CE, Eskilstuna, Sweden

EUROPEAN COLLABORATION

During 2014 the department was involved in the 7th Framework Program of the European Commission in the below listed projects;

- PRACE Consortium
- SMErobotics Consortium
- Flexi-Fab Consortium
- HYCON 2

Staff

During 2014 the staff situation at Automatic Control remains unchanged. Four new PhD students have been employed. We have also had the pleasure of hosting several international guests for shorter or longer periods.

In the coming parts the personnel and its acitivites will be described.

Picture taken at the yearly Kick-off meeting. This time at Erikstorps Kungsgård in Landskrona, situated at the city golf course

STAFF

PERSONNEL AND VISITORS

PROFESSORS
Årzén, Karl-Erik
Åström, Karl Johan, senior professor
Bernhardsson, Bo, deputy head of department
Eker, Johan, adjoint professor
Hagander, Per, professor emeritus
Hägglund, Tore, head of department
Johansson, Rolf
Rantzer, Anders
Robertsson, Anders
Wittenmark, Björn, professor emeritus

ASSOCIATE PROFESSORS
Cervin, Anton (on leave 50-100%)
Como, Giacomo
Johnsson, Charlotta (on research leave until July)

ASSISTANT PROFESSOR
Maggio, Martina

RESEARCH ENGINEERS
Andersson, Leif (30%)
Andersson, Pontus
Blomdell, Anders
Holmstrand, Martin
Nilsson, Anders

ADMINISTRATORS
Borgeram, Lizette (parental leave from February)
Nilsson, Ingrid (80%)
Nishimura, Mika (deputy for Lizette Borgeram)
Rasmusson, Monika (65%)
Westin, Eva

POSTDOCTORS
From, Pål Johan
Giselsson, Pontus (on research leave)
Khong, Sei Zhen
Lovisari, Enrico (until August)
Papadopoulos, Alessandro V. (from February)
Perninge, Magnus

PHD STUDENTS
Andersson, Alina (b. Rubanova)
Antonsson, Jacob
Bagge Carlson, Fredrik
Berner, Josefin
Berntorp, Karl (until October)
Cescon, Marzia (until May)
Dellkrantz, Manfred
Dürango, Jonas
Garpinger, Olof (80%)
Ghazaei, Mahdi
Grussler, Christian
Hast, Martin
Ingesson, Gabriel
Johnsson, Ola
Karlsson, Martin (from April)
Lidström, Carolina
Lindberg, Mikael
Linderoth, Magnus (until May)
Lindholm, Anna (until February)
Madjidian, Daria
Magnusson, Fredrik
Mannesson, Anders
Millnert, Victor (from September)
Nilsson, Gustav
Nordh, Jerker
Olofsson, Björn
Petersson, Anders (50%)
Romero Segovia, Vanessa (until August)
Soltesz, Kristian (until February)
Sörnmo, Olof
Ståhl, Fredrik
Stemmann, Meike
Stolt, Andreas
Theorin, Alfred
Troeng, Olof (from October)
Xu, Yang

PROJECT ASSISTANT

Cairén, Patrik (January-June)

LONGER AND SHORTER STAYS

Aley, Ahmed; visiting PhD student, Umeå University (July)

Annergren, Mariette; visiting PhD student, KTH (from December)

Li, Yuling; PhD scholarship holder, University of Science and Technology Beijing, China

Santiago Rodriguez, José; MSc student (connection with Modelon) (February-June, September-December)

Yamada, Takayoshi; visiting professor, Gify University, Japan (from March)

LCCC FOCUS PERIOD

LCCC Focus period on Cloud Control, May 2014

Ali Eldin Hassan, Ahmed; Umeå University, Sweden

Anastasi, Gaetano; HPC Laboratory, CNR Italy, Pisa, Italy

Berekmeri, Mihaly; University of Grenoble, France

Gambi, Alessio; TU Vienna, Austria

Ibdunmoye, Olumuyiwa; Umeå University, Sweden

Klein, Cristian; Umeå University, Sweden

Krzywda, Jakub; Umeå University, Sweden

Mehta, Amardeep; Umeå University, Sweden

Robu, Bogdan; University of Grenoble, France

Truong, HongLinh; TU Vienna, Austria

Yao, Jianguo; Shanghai Jiao Tong University, China

LCCC Focus period on Dynamics and Control in Networks, October 2014

Carli, Ruggero; University of Padova, Italy

Carvalho, Rui; University of Cambridge, UK

Chen, Wei; Hong Kong University of Science and Technology, China

Colombino, Marcello; ETH Zürich, Switzerland

Forni, Fulvio University of Liège, Belgium

Prof. Georgiou, Tryphon; University of Minnesota, USA

Gerencsér, Balázs; University of Louvain, Belgium

Prof. Hendrickx, Julien; UC Louvain, Belgium

Krishnamurthy, Dvijotham; CalTech, USA

Liu, Ji; University of Illinois at Urbana Champaign, USA

Manchester, Ian; University of Sydney, Australia

Pates, Richard; University of Cambridge, UK

Riehl, James R.; University of Groningen, The Netherlands

Rossi, Wilbert Samuel; Politecnico di Torino, Italy

Schiffer, Johannes; TU Berlin, Germany

Prof. Slotine, Jean-Jacques; Massachusetts Institute of Technology, USA

Summers, Tyler; ETH Zürich, Switzerland

Tanaka, Takashi; MIT, USA

Trimpe, Sebastian; Max Planck Institute for Intelligent Systems, Tuebingen, Germany

Yamamoto, Kaoru; University of Cambridge, UK

STAFF ACTIVITIES

Andersson (Rubanova), Alina
PhD student since October 2009. Her research is part of the project Active Control of Compressor Based on New Methods of Nonlinear Dynamic Feedback Stabilization in cooperation with Prof. A Shiriaev, Umeå University.

During second half of the year she has been on parental leave.

Andersson, Leif
MSc, Research Engineer since 1970. Leif started at the department with responsibility for the teaching and research laboratory. After some years he drifted to computer maintenance and became computer manager. He resigned formally in 2012, but was immediately rehired on 30%.

A large part of his time the past year has been spent updating the department publication database with entries for older publications. The aim has been to have all publications going back to the department start in 1965 registered in the database, to a large extent including fulltext.

Andersson, Pontus
Research Engineer at the department since May 2012.

His main tasks include maintenance and development of laboratory equipment and also mechanic and electronic design and implementation.

Antonsson, Jacob
Jacob has been a PhD student at the department since august in 2013. He is interested in statistical modeling and inference for complex systems, such as nonlinear state-space models and high-dimensional regression models. He tries to apply state-of-the-art research results in those areas in applied fields like statistical genetics and robotics.

Since Octobor 2014 he has been on a visit to the Pasteur Institute in Paris, where he has been working on modeling associations between immunological and clinical variables and the genome. Before he left for Paris he was a teaching assistant for the systems identification course.

Årzén, Karl-Erik
Professor (2000), PhD (1987) and joined the department in 1981. His research interests are real-time and embedded control, real-time systems, cloud control, feedback computing, and programming languages for control.

Co-director for the strategic research area ELLIIT on IT and mobile computing. During the year he has primarily been involved in the VR project Feedback-based resource management for embedded multicore platforms and in the SSF project ENGROSS.

He has been responsible for and taught the undergraduate courses Real-Time Systems and Market-Driven Systems. He is partly or fully involved in the supervision of four PhD students.

Åström, Karl Johan
Professor in Automatic Control since 1965 and founder of the department, emeritus from 2000, senior professor since 2010. He co-supervise PhD students on PID control and auto-tuning.

Bagge Carlson, Fredrik
With the department since June 2013 and graduate student since January 2014.

Teaching assistant in Realtime systems and project supervisor in FRT090 Projects in Automatic Control.

Researcher in EU project Flexifab with focus on state estimation and robot control under influence of large process forces

Berner, Josefin
MSc in Engineering Physics. PhD student since August 2012. Her research interests are in automatic tuning of PID controllers and within the ELLIIT project on control of energy usage in buildings. During the year she has also taken some courses, been a teaching assistant in the course on multivariable control and supervised Master Thesis students.

Bernhardsson, Bo
PhD 1992, Professor since 1999, has also worked at Ericsson for 9 year.

Director of Studies for the PhD education, vice head of the department and a member of the LCCC board. His research interests are in linear systems, applications of control theory and the connection between communication and control theory.

During 2014 he gave the two PhD courses: Linear Systems and Game Theory.

During the year he was supervisor or co-supervisor of 10 PhD students.

Berntorp, Karl
MSc in Engineering Physics (2008), doctoral student since February 2009. This year he defended his doctoral thesis *Particle Filtering and Optimal Control for Vehicles and Robots* in May 2014.

Blomdell, Anders
Research Engineer at the department since 1988. Heavily involved in almost all aspects of Robotics research at the department, also responsible for the department network and lab computers for teaching and research.

During 2014 more services were moved to virtualized servers, and a lot of work was done exploring various ways to bring resilience to our data storage, while still maintaining ease of use and maintenance, during that work a substantial amount of work went into exploring and fixing various problems with the cloud storage product Gluster (http://www.gluster.org/). Unfortunately the jury is still out on which way to go for our storage; but the saga continues...

This years Automatica Trade Fair in Munich was a total success from the research engineer perspective; we came down with a fully equipped portable workshop (with built in refrigerator) and for the first time ever, we did not have to scuttle out to buy any tools in order to build solutions to any of the problems that occurred during the week. A perfect illustration of research in progress.

Borgeram, Lizette
Administrator at the department since February 2012. During 2014 she has been on parental leave and Mika Nishimura has been her deputy.

Cervin, Anton
Associate Professor, Docent (2007, 2008), PhD (2003) and joined the department in 1998. Anton's research interests include real-time systems, event-based and networked control, and computer tools for analysis and simulation of controller timing.

During the year he has been on parental leave for 7.5 months. The rest of the year he has been working part time (50-80%) in industry.

Como, Giacomo
PhD (2008), Docent (2012). He has been with the faculty at the Department of Automatic Control since 2011 and was promoted Associate Professor (universitetslektor) in 2013. He is serving as main supervisor of Gustav Nilsson and co-supervisor of Christian Grussler. His research interests are in Dynamics, Information, and Control in Networks, with applications to transport and infrastructure networks, as well as social and economic networks.

In 2014, he has taught the undergraduate course Nonlinear Control (both in Spring and Fall) and developed a new undergraduate course on Network Dynamics (FRTN30), first offered in Spring 2015. In November-December 2014 he taught a PhD course at the Dutch Institute for Systems and Control (DISC).

He will be serving as chair of the International Program Committee of 5TH IFAC workshop on Distributed Estimation and Control in Networked Systems (NecSys 2015).

Dellkrantz, Manfred
MSc in Engineering Computer Science since November 2011, PhD student at the department since June 2012. Works with automatic elasticity control, load balancing and delay compensation of applications deployed in cloud environments.

Involved in teaching the Real Time Systems course during the spring.

Dürango, Jonas
MSc in Engineering Physics, with the department as a PhD student since 2010, supervised by Bo Bernhardsson and Martina Maggio.

In the last year he has mainly been working on performance aware cloud applications within the Cloud Control project. He has also been active in teaching graduate courses at the department, as well as taking courses himself.

Eker, Johan
Johan is an Adjoint Professor at 20% and a Principal Researcher at Ericsson Research at 80%. His main research areas are resource management for real-time systems and cloud computing and tools and methodologies for many- and multicore systems.

From, Pål Johan
PhD 2010. He has been a researcher with the LCCC since July 2011. His research includes surgical robotics.

Garpinger, Olof
Lic. Tech., graduate student since August 2005 with a break from January 2010 to September 2012. Hi is currently on a 80% work load. Olof is doing research on software-based optimal design methods for PID control and is part of the Process Industrial Centre at Lund University. He is supervised by Professor Tore Hägglund.

Ghazaei Ardakani, M Mahdi
Since the beginning of 2012, he is with the Automatic Control Department as a PhD student. His research interests include robotics, system and control theory, machine learning and physical modeling.

During 2014, he was involved in PRACE project and contributed with the implementation of a robust open-loop strategy for lead-through programming of YuMi robot, a dual-arm concept for demonstrating tasks, and an architecture for rapid programming of ABB robots. His efforts contributed to the successful finalization of the project.

In the capacity of teaching assistant and lab supervisor, he was involved in basic control, system identification, and applied robotic courses.

Giselsson, Pontus
Ass. Prof, PhD (2012). During 2014, Pontus pursued post doc studies at Stanford University under the supervision of Prof. Stephen Boyd. His research interests are within optimization and its wide range of applications.

Grussler, Christian
Since 2012, he is a PhD-student at Lund University. So far, his research interests included model reduction, cone invariant systems, low-rank approximations and numerical analysis.

During the spring term 2014, he was a teaching assistant in the courses: Control Theory and Non-Linear Control and Servo Systems. In the fall term he was a visiting research student at California Institute of Technology hosted by Venkat Chandrasekaran.

Hagander, Per
Senior Professor, PhD (1973). Per has been with the department since 1968 and works with linear system and with applications in biotechnology and medicine.

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 and decentralized control structures.

Tore Hägglund is also head of the department

and deputy centre director of "Centre for Research and Competence Development for the Process Industry", PIC-LU.

Hast, Martin
MSc in Engineering Physics, PhD student since February 2010. Martin's research interests are in optimal controller design for disturbance attenuation for both feedforward and PID-controllers, supervised by Prof. Tore Hägglund. Martin has worked together with Karl Johan Åström and Stephen Boyd on tuning of SISO and MIMO PID-controllers using convex optimization methods. Work related to tuning rules for low-order feedforward controller has also been conducted and tuning rules for optimal set-point weighting has been developed.

Martin has previously been involved in the development of a Modelica-based verison of TrueTime and has been a teaching assistant in the basic control course, the automatic process control course and the project course.

Holmstrand, Martin
Research engineer since December 2013. His work is manly related to robotics, and spends most of his day working with the EU-project FlexiFab.

Ingesson, Gabriel
PhD student since January 2013. He is working with Professor Rolf Johansson in the KCFP PPC Control project, which is a cooperation with the Division of Combustion Engines. Gabriel is studying how the burning rate and the ignition delay are affected by fuel-injection timings in partially premixed combustion engines. He spent a huge part of 2014 setting up a new multi-cylinder test cell in the newly installed combustion engine lab.

Gabriel has during the year been a teaching assistant in the Automatic Control basic course and in the Real-Time Systems course. He also supervised a Master Thesis project on Model Predictive Control.

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 participates and leads the research projects SSF ProViking ProFlexa, Vinnova PFF Diesel HCCI, Vinnova NFFP5 Adaptive Control, KCFP Control, ROSETTA, SMErobotics, COMET, PRACE and VR Active Control. He is coordinating director for Robotics Laboratory with cooperation partners from Dept Computer Science and industrial partners. He has industrial cooperation with ABB Robotics, ABB Corporate Research, SAAB, Volvo.

He is responsible for the three courses FRT041 System Identification, FRTN15 Predictive Control, and FRTF01 Physiological Models and Computation. He is also supervisor for a number of Master thesis projects and PhD students.

Johnsson, Charlotta
Research Associate, PhD (1999). Charlotta has been at the department since 1993 except for 4 years (2000-2004) when she worked in industry. Charlotta's main research interest is in Production Control, Batch Control Systems, Operations Management and Pedagogy. She is also part of the management team for the research centers LCCC, PIC-LU and LISA.

Charlotta is serving as the Program Leader for Technology Management, a joint programme run by Lund Institute of Technology and the School of Economics and Management at Lund University. During the year, Charlotta has been involved in a variety of courses.

Charlotta is spending the academic year 2013/2014 with Center for Entrepreneurship and Technology (CET), Fung Institute, University of California, Berkeley, CA, USA. She is participating in the development of the Berkeley Method of Entrepreneurship (BMoE), a new holistic method for entrepreneurship training, as well as in the execution of the Engineering Leadership Professional Program (ELPP), an executive programme for engineers.

Johnsson, Ola
Tech. Lic, MSc in Biotechnical Engineering, graduate student since August 2010. Works within the field of fermentation control, in cooperation with Novozymes A/S.

Spent 2014 performing experiments in production scale fermentation processes at Novozymes for development and evaluation of a process monitoring method, as well as pilot scale experiments for organism characterization.

He has also taken PhD courses at the Dept of Automatic Control, participated in teaching courses for engineering students given by the department and supervised a MSc thesis.

Karlsson, Martin
MSc in Engineering Physics. PhD student since May 2014. His research interests are within robot positioning within the ENGROSS project.

During the year he has taken some courses, and been a teaching assistant in the Basic Course, Process Control / Systems Engineering and Projects in Automatic Control.

Khong, Sei Zhen
PhD. He joined the department as a postdoctoral researcher in August 2013.

His research interests include distributed analysis of heterogeneous networks, robustness of feedback interconnections, and extremum seeking control of nonlinear systems.

Klein, Helena
Archivist and Librarian. She has been lent to us from the University Archive Center to help us register and archive our old documents so that they are available and searchable. Helena, in her role of librarian, has registered publications and organized in library issues.

She has also given short lectures on how to profitably use all publication databases available to us.

Lidström, Carolina
MSc in Engineering Physics since May 2013. PhD student at the department since June 2013.

Her research interests include distributed control and its applications to power systems, such as distributed control of the balance between demand and production of power on the electricity grid.

During the year she has completed several courses and been a teaching assistant for the course titled Physiological Models and Computation.

Lindberg, Mikael
MSc and Tech Licentiate. He has been with the department for 7 years (parental leave not included) and defended his doctoral thesis *From Competitive to Cooperative Resource Management for Cyber-Physical Systems* in June 2014.

Lovisari, Enrico
Enrico was a postdoc researcher at the Dept of Automatic Control between September 2012 and August 2014. He has been working in collaboration with Prof. Giacomo Como and Gustav Nilsson and with Ketan Savla from USC, on the topic of optimal routing policies in transportation systems.

Madjidian, Daria
Daria has a MSc in Electrical Engineering (2005).

His research interests are control theory with emphasis on distributed control, coordination and optimization, as well as application of control theory to wind energy systems.

He has been a PhD student since 2008 and he defended his doctoral thesis *Low-Rank Distributed Control with Application to Wind Energy* in June 2014.

Maggio, Martina
She has been a Postdoctoral Researcher at the department since January 2012 and recently became an Assistant Professor in August 2014. She is leading the project on control for power and temperature in computing datacenter, that has strong connections with the cloud control project.

During 2014, she has been teaching the Pro-

cessreglering/Systemteknik (Basic Process Control) for environmental and chemical engineers and the Basic Automatic Control course at the Zhejiang University in China. She also supervised a thesis on resource allocation for camera platforms, performed in a joint collaboration with Axis Technology. She is co-supervising Jonas Dürango towards his PhD studies.

Her research interests are at the border between computing systems and control theory. In the cloud control project, she is mainly working on control for software applications. Software applications are now largely deployed in public or private clouds. Cloud applications and infrastructures should withstand rapid changes and sudden variations, like flash crowds. Usually these variations are supposed to be absorbed by the cloud provider, with autoscaling mechanisms. This project applies control theory to cloud computing, to build reliable and dependable infrastructures and applications, even when the cloud provider does not take care of absorbing fluctuations. Applications can handle these variations through a similar mechanism to brownouts in power grids. Building a brownout-compliant application requires minimal modifications to the original source code.

She is also involved with embedded systems research. In modern computing systems applications must share finite computational resources in a coordinated way. Some application are also able to dynamically adjust their requirements to provide different service levels. Traditionally the problem of distributing the resources and selecting the application service levels are treated jointly, to produce an optimal solution, however with a high overhead. Her research aims at decoupling the resource allocation and the application adaptation problem, lowering the complexity of both the application manager and the resource manager. This also apply to power and temperature requirements, that should be fulfilled despite changing environment and execution platform.

Magnusson, Fredrik
MSc in Engineering Mathematics (2012), PhD student since February 2012. Fredrik's research regards numerical and symbolic algorithms for solution of non-convex dynamic optimization problems and is a part of the research area Modeling Support for Design and Verification of LCCC.

He was a teaching assistant in the basic control course during the spring and the nonlinear control course during the fall. He also supervised two Master's theses.

Mannesson, Anders
Lic. Tech., graduate student since June 2010. He joined the department after working 4 years as analog ASIC designer in the electronics industry. He is now working together with Prof. Bo Bernhardsson on improving positioning, radio channel estimates, and link adaption within the ELLIIT project. His main research topics involves estimation, statistical signal processing, and optimization.

June 2013, he defended his licentiate thesis called *Joint Pose and Radio Channel Estimation*.

During the year he has been a teaching assistant for the undergraduate courses Market-driven System and Multivariate Control.

He plans to defend his thesis in 2015.

Millnert, Victor
PhD student at the department since September 2014. His research interest is within cloud computing.

He has been a teaching assistant for the Basic Control Course, as well as for the Real-Time Control course, both during the fall 2014.

Nilsson, Anders
PhD (2006), research Engineer since 2010. Spends most of his time looking after the department computers and their software.

Nilsson, Gustav
MSc in Engineering Physics (2013). Gustav has been a PhD student at the department since

September 2013. His research interests are modeling and distributed control of large scale systems with applications in traffic networks.

In May he visited Grenoble Traffic Lab, France for three weeks.

During the year, he has also been a teaching assistant in the basic control course and involved in the development of the new master's level course in Network Dynamics.

Nilsson, Ingrid
Finance officer at the department since 2009. Ingrid is mainly responsible for the financial transactions at the department such as bookkeeping, budget managing and balancing of the books. Another big task is administration of research projects and reporting to the sponsors.

Nishimura, Mika
Born in Japan. Administrator at the department since 2014. She handles student register and exam results in Ladok and has contact with the printing office about dissertations and other publications.

She is responsible for the library and archives and for purchase of office supplies, books and furniture.

She updates parts of the web pages and keeps keys in order among other service oriented tasks.

She also teaches Japanese at Folkuniversitetet in Lund.

Nordh, Jerker
MSc in Engineering Physics, graduate student since August 2010.

During 2014 the teaching duties have been fulfilled by teaching in the Project in Automatic Control course, both during the spring and autumn, and the Real-time Systems course during the autumn.

The research has been focused on applications of non-linear estimation and the development of software to aid in the application of particle methods for non-linear estimation.

Olofsson, Björn
Tech. Lic., MSc in Engineering Physics, Ph.D. student at the department since August 2010. He presented his Licentiate Thesis *Topics in Machining with Industrial Robots and Optimal Control of Vehicles* in April 2013. His research interests are in robotics and optimal motion control.

During the year, he has been active in one EU/FP7-project, SMErobotics. In the project, he is performing research on methods for increasing the position accuracy of machining tasks performed with industrial manipulators. Moreover, methods for modeling and system identification related to task execution with industrial robots are investigated. Within the ELLIIT Excellence Center, he is investigating optimal motion control for mobile robots and vehicles in time-critical maneuvering situations.

He has also participated in graduate courses within control theory and robotics and taken active part in the teaching at the department, both within the undergraduate engineering programs and by supervision of Master Thesis projects. He also organized the Study Circle on Robot Learning and Control, held at the department during the fall semester.

Papadopoulos, Alessandro Vittorio
MSc in Computer Engineering (2010), PhD in Information Technology – Systems and Control (2014). He joined the department as a Postdoctoral Researcher in January 2014. His research interests are cloud control, feedback computing, real-time and embedded systems, cyber-physical systems, modeling and simulation of complex systems, evolutionary game theory, and human-robot interaction.

He has taught the undergraduate Real-Time Systems course together with Prof. Karl-Erik Årzén.

Perninge, Magnus
Postdoc. since January 2013. His research interests are: Power system stability and control, Stochastic control, Operations research. He is working in the ICT-Psi project with project leader

Anders Rantzer.

He has been teaching a PhD course in Optimal Control in the spring of 2014 and gave three lectures in FRTN05 Non-linear Control and Servos Systems in the fall.

He has supervised one MSc student, Karen Kyeyune, master's thesis entitled *Optimizing Control of a Power System during an Emergency.*

He has also been assistant supervisor for PhD-student Carolina Lidström.

Rantzer, Anders

Professor of Automatic Control since 1999 and coordinator of the Linnaeus center LCCC since the start 2008. He has broad interests in modeling, analysis and synthesis of control systems, with particular attention to robustness, optimization and distributed control.

Anders is the main supervisor for several PhD students.

During 2014, he was teaching the courses FRTN10 Multivariable Control, FRT095 Mathematical Modelling and FRT130 Control Theory at the MSc level.

During 2014, he also served as chairman of the Swedish Scientific Council for Natural and Engineering Sciences.

Rasmusson, Monika

Financial administrator at the department since August 2011. As a part of the administrative team, her work includes reimbursements, travel bills, reporting projects, involvement in the budgetprocess among other tasks.

Robertsson, Anders

Professor (2012), Associate professor (2007), "Docent" (2005), Research Associate (May 2003), PhD (1999). Excellent Teaching Practitioner (ETP) in 2007. His main interest is in nonlinear control, robotics and control of computing systems.

Currently he is working on parallel kinematic robots, sensor-data integration and force control of industrial robots in collaboration with ABB Robotics/ABB CRC. The research has been conducted with the LUCAS project, the Robotics Lab, The Linneaus Centre LCCC, ELLIIT network, the ENGROSS-project and the EU funded projects PRACE (FP-7), SMErobotics (FP-7), Flexifab (FP-7). He has also been doing research on admission control in network nodes and control of server systems in cooperation with the Department of Electrical and Information Technology, LTH, Lund University, Ericsson AB, Karlskrona and within the VR-funded CloudControl-project together with Umeå University.

He has been course responsible in project courses on automatic control (FRT090), lectured in Applied robotics (MMKF15) and been examiner for the graduate course on Robot Learning and Control.

He has acted as advisor/co-advisor for (3+7) PhD students and several Master's Thesis project.

Romero Segovia, Vanessa

PhD Student since September 2008. Her research interests are related to Adaptive Control and to the design of measurement noise filters for PID and PI controllers, which can be used in process control applications.

She defended her doctoral thesis *CPU Resource Management and Noise Filtering for PID Control*, and it turned out to be the number 100 of theses defended at the Department of Automatic Control.

Sörnmo, Olof

Lic. Tech., PhD student since May 2010. Olof's main research interests are within robotics, and he is involved in the EU/FP7-project SMErobotics. His research focuses mainly on improving machining processes performed with industrial manipulators, considering both positioning accuracy and cycle-time minimization. Topics include adaptive force control, iterative learning control and reinforcement learning. Additionally, during 2014 Olof worked on frequency-domain ILC of a marine vibrator, to be used for marine seismic acquisition.

Ståhl, Fredrik
Lic. Tech. (2012). Graduate student since 2008 (part-time 2008-2012). Fredrik's main research interests focus on modeling, identification and prediction of blood glucose dynamics.

Teacher assistant in the course *Physiological models and computations*.

Stemmann, Meike
Lic. Tech., graduate student since November 2009. She is working together with Anders Rantzer on control of energy usage in buildings, within the eLLIIT project.

Stolt, Andreas
Lic. Tech., PhD student since March 2010. Andreas main research focus is force controlled compliant assembly and sensor-less force control with industrial robots.

During the spring, he was a teaching assistant in the project course, and during the autumn he was involved in the applied robotics course and the nonlinear control course.

Theorin, Alfred
PhD graduate student at the department since January 2010.

Alfred's main research interests involve control languages and industrial automation and he is working on the Grafchart for Industrial Automation and LISA projects.

During the year he has defended his PhD thesis and he has worked to improve Grafchart and JGrafchart, mainly to enable real-time execution and to add support for LabComm and OPC UA.

During the spring he was a teaching assistant in the Market-driven Systems course as well as supervisor for a master's thesis.

Troeng, Olof
MSc (2012). PhD student since Oct 2014. Prior to joining the department, Olof worked for two years in the aerospace industry.

He is together with his supervisors Bo Bernhardsson, Anders J Johansson and Rolf Johansson working with control of the accelerating fields in the linear accelerator at the European Spallation Source.

Olof has been a teaching assistant in the basic control course and supervised two projects in the project course.

Westin, Eva
PhD in French linguistics. Administrator at the department since 2008 and administrative coordinator from 2012. She handles the overall responsibility of human resources, guests and conferences. She also handles part of the process for research studies.

Eva is the project administrator for the LCCC Linnaeus project. She is part of the workplace health and safety team at the department. She is also part of the Equality group at the Faculty of Engineering and works with these questions at the Department.

Eva is the co-supervisor of a PhD thesis in French linguistics at the Center of Languages and Literature (SOL) at Lund University

Wittenmark, Björn
He joined the department in 1966 and took his PhD in 1973. He became full professor at the department 1989. His main research interests are adaptive control, sampled-data systems, and process control. During 1996-1999 he was prorektor at Lund Institute of Technology and 2003-2008 vice rector at Lund University.

He is emeritus professor at the department since 2010.

Yamada, Takayoshi
Guest Professor at the department from March 2014 to February 2015.

He is an Associate Professor in the Department of Mechanical Engineering at Gifu University, Japan. He received a B.E., M.E., and Ph.D. in Mechanical Engineering from the Nagoya Institute of Technology, Japan in 1991, 1993, and 1995, respectively.

His research interests include Grasping, Manipulation, Sensing, Robotic Assembly, and Automation Systems. He collaborated with Prof.

Rolf Johansson and Prof. Anders Robertsson. He contributed to Projects in Automatic Control and Robotics Week 2014.

Xu, Yang
MSc in Automatic Control. PhD student since June 2012. Yang's main research interests involve integrated scheduling and synthesis of networked embedded event-based control systems. He is involved in the ELLIIT project.

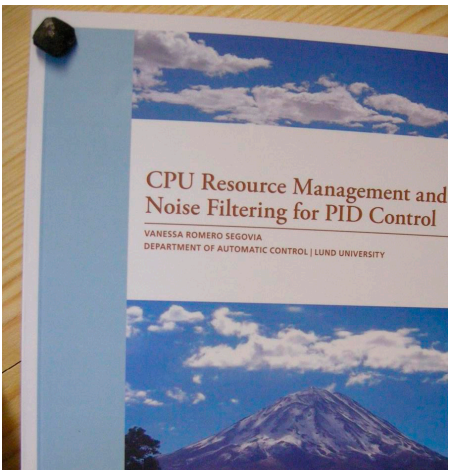
During this year he was a teaching assistant in Automatic Control course, in Lund University and Zhejiang University.

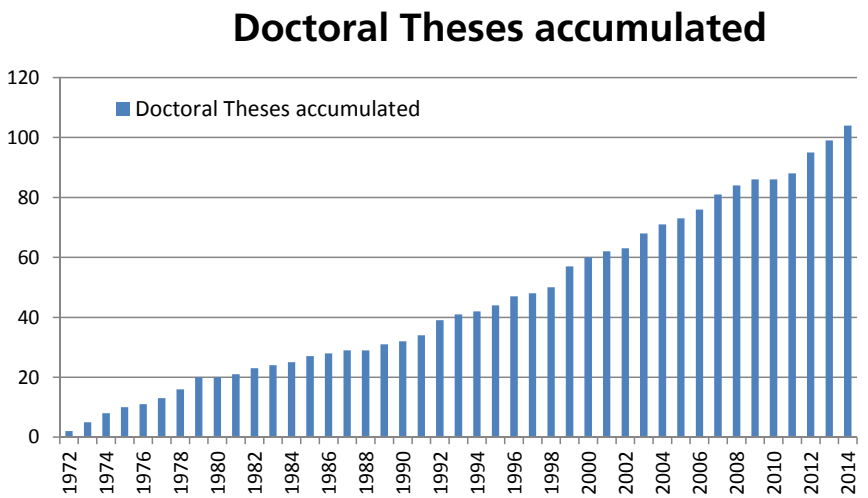
EVENT

1st of April we celebrated the 100th thesis by inviting all the Doctors who had already defended their thesis at the department of Automatic Control including other alumni. The 100th thesis was written by Vanessa Romero Segovia and entitled *CPU Resource Management and Noise Filtering for PID Control.* She was not present in person but connected by computer directly from Paris. Karl-Erik Årzén, as her supervisor, acted on her behalf in exhibiting her thesis. It was a nice get-together and those who had accepted the invitation really have a fun event to remember.

Ever since this event, we have started a new tradition in letting the Doctor to be exhibit his/her thesis before defending it a couple of weeks later.

As we now have space for more theses to come, the rumour says it will be an "all-time-high" in number of theses to be defended during next year.



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AWARDS

Maja and Erik Lindqvist Foundation award
The board of the "Maja and Erik Lindqvist foundation" awarded Martina Maggio and the Department of Automatic Control, Lunds Tekniska Högskola, with 315 000 SEK, for the investment to equip a cloud laboratory that will be used in the cloud control project.

Young Author Price at IFAC, Cape Town, South Africa
Pontus Giselsson received the Young Author Price at 2014 IFAC World Congress in Cape Town for his paper entitled *Improved Fast Dual Gradient Methods for Embedded Model Predictive Control*. He also had another finalist paper for the same price entitled *Improved Dual Decomposition for Distributed Model Predictive Control*.

Grant from Vinnova SWElife program
During the year, Fredrik Ståhl received a 330.000 grant from the Vinnova SWElife program to develop a prototype of a decision support system for glucose control in insulin-treated diabetes.

Sten K Johnson Foundation scholarship
Fredrik Ståhl was awarded a scholarship of 100.000 kr from the Sten K Johnson Foundation.

Knut & Ragnvi Jacobsson Foundation scholarship
Charlotta Johnsson received a scholarship from *Familjen Knut och Ragnvi Jacobssons stiftelse* for continuing her work in entrepreneurship and leadership in cooperation with UC Berkeley.

ASSIGNMENTS

BOARD MEMBER

Årzén, Karl-Erik
Member of the Board for the ELLIIT strategic research area project.
Member of the Steering Committe for the International Conference on Cyber-Physical Systems (IC-CPS).
Member of the Strategic Management Board for the EMSIG Special Interest Group on Embedded Systems.
Member of Research Board of Mathematics, Physics & Information and Communication Technology, Faculty of Engineering, Lund University.
Member of the Executive Committee for the IEEE Computer System's Technical Committee on Real-Time Systems (TCRTS).

Hägglund, Tore
Expert member in legal proceedings for patent at Svea Court of Appeal.

Johnsson, Charlotta
Board member in Technology Management Advisory Board at Lund University.
Board member at PTW at Högskolan Väst, Trollhättan, Sweden.
Board member at SESAM-Sverige, a network for industrial automation.
Board member at SmartFactory TU Kaiserslautern, Germany.
Board member of LCCC.

Rantzer, Anders
Chairman of the Scientific Council for Natural and Engineering Sciences within the Swedish Research Council.
Member of the Steering Committee for the International Symposium on Mathematical Theory of Networks and Systems.

Wittenmark, Björn
Board member of the research programs EASE and PIC-LU.
Member of Editorial Board: Journal of Forecasting
Member of the Research Board of Gyllenstiernska Krapperupsstiftelsen.
External expert for senior lecturer in automatic control at Linköping University.

MEMBER OF INTERNATIONAL PROGRAM COMMITTEE (IPC)

Årzén, Karl-Erik
Member of the Program Committee for Euromicro Conference on Real-Time Systems (ECRTS), Madrid, Spain, July 9-11, 2014.
Program co-chair for the Modelica conference, Lund, March 10 - 12, 2014.
Member of the Program Committee for the 9th International Workshop on Feedback Computing, Philadelphia, PA, June 17, 2014.

Member of the Program Committee for the 20th IEEE Real-Time and Embedded Technologu and Applications Symposium, Berlin, Germany, April 15-17, 2014.

Johansson, Rolf

Technical Associate Editor (TAE)—Automotive Control, IFAC World Congress 2014, 24-29 August 2014, Cape Town, South Africa.

Co-chair & IPC Member, The 8th International Workshop on Innovation and Commercialization of Micro & Nanotechnology (ICMAN2014), 9-12 Nobvember, 2014, Suzhou, Jiangsu, China.

Member of Advisory Committee, IEEE BioRob 2014, IEEE International Conference on Biomedical Robotics and Biomechatronics (BioRob2014), August 12-15, 2014, São Paolo, Brazil; Sponsored by IEEE Robotics and Automation Society & IEEE Engineering in Medicine and Biology Society.

IPC Member, UKACC International Conference on Control (CONTROL 2014), 9-11 July 2014, Loughborough, UK.

IPC Member, 11th Conference on Automatic Control (CONTROLO2014), July 21-23, 2014, Porto, Portugal.

Maggio, Martina

Program chair of the 12th IEEE International Symposium on Parallel and Distributed Processing with Applications (ISPA), held in Milan, Italy, 26-28 August 2014.

Member of the Technical Program Committee for the 20th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA), held in Chongqing, China, 20-22 August 2014.

Member of the Technical Program Committee for the 9th International Workshop on Feedback Computing (Feedback Computing), held in Philadelphia, USA, 17 June 2014.

Member of the Technical Program Committee for the 6th Workshop on Adaptive and Reconfigurable Embedded Systems (APRES 2014) held in Berlin, Germany, April 14, 2014.

Member of the Poster Committee for the 8th IEEE International Conference on Self-Adaptive and Self-Organizing Systems, held in London, United Kingdom, 8-12 September 2014.

Co-organizer of the GI-Dagstuhl seminar "Control Theory meets Software Engineering", held at Dagstuhl, September 14-19, 2014, website for more information http://www.dagstuhl.de/14382, http://www.martinamaggio.com/dagstuhl.

Hägglund, Tore

International Workshop on Event-Based Systems (EBS 2014), Barcelona, Spain.

Rantzer, Anders

Chairman of the IPC for European Control Conference, Ålborg, 2016.

Member of the IPC for Indian Control Conference 2015.

Member of the 1st IFAC Conference on Modelling, Identification and Control of Nonlinear Systems (MICNON 2015).

Robertsson, Anders

Member of the Steering Committee and the Program Committee of Feedback Computing 2014.

OPPONENT AND MEMBER OF EXAMINATION COMMITTEE

Bernhardsson, Bo

Member of the examination committees for Israel Diaz, EIT Lund, Chitrupa Ramesh, KTH, and Stefan Ingi Adalbjörnsson, Mathematics LU.

Cervin, Anton

Member of the PhD Examination Committee for José Araújo, KTH, Stockholm, October 24.

Como, Giacomo

Member of PhD Examination Committee for Dominik Pisarski, INRIA Rhone-Alpes, Université de Grenoble, France, September 16, 2014.

Member of PhD Examination Committee for Kittipong Kittichokechai, School of Electrical Engineering, KTH, Stockholm, June 3, 2014.

Hägglund, Tore

Opponent for the PhD thesis of Erik Henriksson, KTH Stockholm, March 14.

Member of the Examination Committee for the PhD thesis of Ignacio Fernández Sedano, University of Almeria, Spain, June 16.

Member of the Examination Committee for the PhD thesis of Margarida Martins da Silva, Uppsala University, Sweden, November 21.

Opponent for the PhD Thesis of Vesa-Matti Tikkala, Alto University, Helsinki, December 5.

Johnsson, Charlotta

Main opponent for PhD-thesis *Flexible and transparent Allocation of Production Process KPI to Business Software Systems*, Tobias Gerber, Technischen Universität Kaiserslautern, Kaiserslautern, Germany, 2014-02-03.

Rantzer, Anders

Member of PhD Examination Committee for Richard Pate, Cambridge University.

Member of PhD Examination Committee for Gunn Larsen, Groningen University.

Member of PhD Examination Committee for Gerd Simon Schmidt, University of Stuttgart.

Robertsson, Anders

Member of Evaluation Committee for the PhD Thesis, *Feed-back Control of Friction Stir Welding* for by Jeroen De Backer,University West, Sweden.

Chairman at Mikael Lindberg's PhD disseration.

Opponent to PhD thesis *Collision Detection and Obstacle Avoidance for Industrial Robots in Unstructured Environments* by Knut Berg Kaldestad, University of Agder, Grimstad, Norway.

Member of the Examination Committee (+chair) for PhD Thesis by Andreas Myklebust, Linköping University, Sweden.

Member of the Examination Committee to evaluate the PhD Thesis of Niccolo Tosi, KU Leuven, Belgium.

ADVISORY COMMITTEES AND WORKING GROUPS

Årzén, Karl-Erik
Member of the Norwegian committee on assessment of competence for the title of full professor in IT
Member of the Royal Swedish Academy of Engineering Sciences (IVA).

Åström, Karl Johan
Member of the United Technology Technical Advisory Committee for systems and control.

Como, Giacomo
Member of Technical Program Committee IEEE International Symposium on Information Theory 2014.

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

Johnsson, Charlotta
Voting member in the Standardisation Committee ISA95 and an information member in the Standardization Committees ISA88 and ISA99.
Member in SIS and SEK and serves as the Swedish expert in the international IEC 62264 and ISO 22400 standards.

Rantzer, Anders
Member of the Advisory Board for Lecture Notes in Control and Information Sciences at Springer Verlag Heidelberg.
Member of the IEEE Control System Society Technical Committee on Nonlinear Systems and Control.
Member of the IFAC Technical Committee on Nonlinear Systems.
Member of the Organizing Committee for the IMA Thematic Program 2015/16 on "Control Theory and its Applications".

OTHER ASSIGNMENTS

Årzén, Karl-Erik
Associate Editor for Real-Time Systems Journal.
Area Editor for the Leibniz Transactions on Embedded Systems (LITES).

Johansson, Rolf
Editor, Mathematical Biosciences, (Elsevier).
Editor, Intelligent Service Robotics (ISR), (Springer).
Associate Editor, International Journal of Adaptive Control and Signal Processing, (Wiley).
Associate Editor, Chinese Journal of Scientific Instrument, (China Instrument and Control Society).
Member of Editorial Board, Robotics and Biomimetics, (Springer).

Johnsson, Charlotta
Member in UN3 (utbildningsnämnd 3) at LTH.
Serving as the IFAC Liaison with IEC 65A.
Editor of ISO 22400 Part 1.
Member in SEK, SIS, and MESA.

Maggio; Martina
Journal Editor: Associate Editor for the ACM Transaction on Embedded Systems, in the specific area of Self-Aware/Self-Adaptive Computing.

Westin, Eva
Representative for Automatic Control in and member of the Equality group (JäLM) at the Faculty of Engineering.

LONGER VISITS ABROAD

Antonsson, Anton
Pasteur Institute, Paris, France during November-December, 2014.

Giselsson, Pontus
Postdoc in the Electrical Engineering Department at Stanford University, USA , starting in September 2013, ending December 2014.

Johnsson, Charlotta
Center for Entrepreneurship and Technology (CET), University of California Berkeley, CA, USA, August, 2013 – June 2014.
Zhejiang University, Hangzhou, China. 12-20 September, 2014 and 10 October-3 November, 2014.

Maggio, Martina
Lecturer of FRT010 Automatic Control, Basic Course at Zheijang University, Hangzhou, China,. during November-December, 2014.

Xu, Yang
Zheijang University, Hangzhou, China for two months during the fall.

Economy

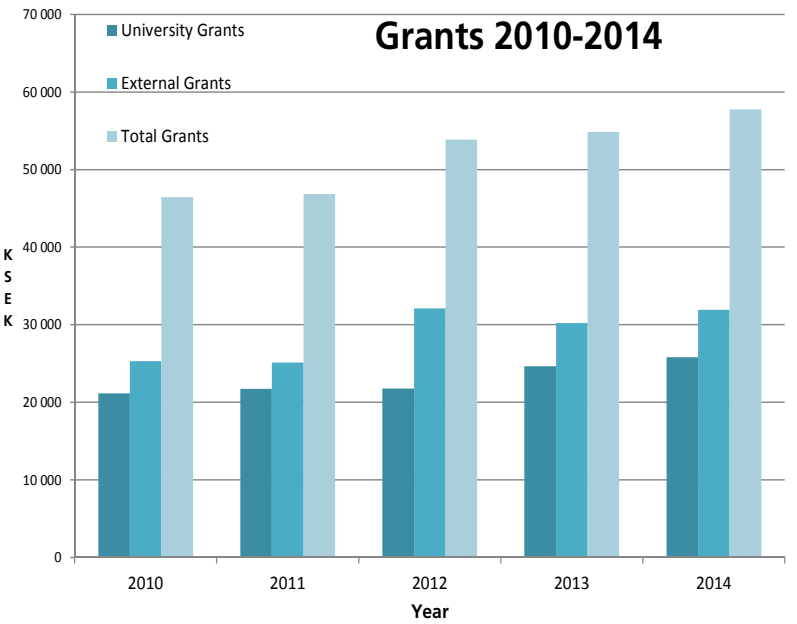
This chapter contains an overall view of the Economy and Funding

ECONOMY

The turnover for 2014 was 58 MSEK, an increase by 3 MSEK since 2013. About 45% of the income comes from Lund University and 55% from external grants. The distribution is shown below.

The activity and the number of employees have increased substantially in the last few years, mainly because of the Linnaeus grant "Lund Center for Control of Complex Engineering Systems" - LCCC, and "The Linköping–Lund Initiative on IT and Mobile Communication" - eLLIIT, funded by the Swedish Research Council. However, now the situation seems to have stabilized, the number of employees is about the same 2014 as 2013. The department participated in 4 projects funded by the European Union, EU, during 2014 and The Swedish Foundation for Strategic Research has also provided substantial support of the activities.

The block grants from VR and some of the SSF projects are long range. Several projects do, however, have a duration of only two years. To match these with the length of a PhD position, i.e. 5 years, we have a long-term internal research planning, and we are careful to bid on projects that fit into our research plan. This has proven efficient to match short-term funding, research planning and personnel.



FUNDING

During 2014 we had the following grants:

VR – Linnaeus grant Lund Center for Control of Complex Engineering Systems LCCC
VR – Resource Allocation and Control of Distributed Service Management Systems
VR – Information Dynamics over large-scale networks
VR – Feedback Based Resource Management for Embedded Multicore Platforms
VR – Simultaneous Movement Tracking and Radio Channel Estimation
VR – Event-based control components with performance bounds
VR – Active Control of Compressor Systems Based on New Methods of Nonlinear Dynamic Feedback Stabilization
VR – Scalable and Resource-Constrained Control Systems
VR – Cloud Control
VR – Remuneration for Anders Rantzers´ function as a Member of the Scientific Councilfor Natural and Engineering Sciences within the Swedish Research Council 2013-2015
VR – Power and temperature control for large-scale computing infrastructures
VR – Methods for control of large-scale dynamical systems
Energimyndigheten - Predictive Control and System Optimisation of Wheel Loaders
Vinnova – Line Information System Architecture, LISA
Vinnova-Saab – Adaptiv Control in Flying Vehicles
Vinnova- Control of batch processes in biotechnology and biopharma industry
Vinnova – PiiAbio
Vinnova – PiiA-Nyckeltal i svensk processintustri
Vinnova – Nästa generations automatinställare för PID-regulator
SSF – Process Industrial Centre at Lund University, PICLU
SSF – Enabling GROwing Software Systems, ENGROSS
SSF – Productiv Flexibel Automation, ProFlexa++
SSF – ICT platform for lasting infrastructure, ICT-PSI
SSF – Process Industrial Centre at Lund University, PICLU 2
EU – FP7 257462 Highly-complex and networked control systems, HYCON
EU – FP7 287787 The European Robotics Initiative for Strengthening the Competitiveness of SMEs in Manufacturing by integrating aspects of cognitive systems, SMErobotics
EU – FP7–SME-2013-606156-FlexiFab – Flexible fabrication of lightweight aluminium transport structures, FlexiFab
EU – FP7 285380 The Productive Robot Apprentice, PRACE
The Linköping–Lund Initiative on IT and Mobile Communication, ELLIIT
Marie Curie – Virtual Cyber-Physical Systems
Toyota Moter Corporation – Project on Nonlinear Model Reduction
SKB - Control of Stirwelding Process for Sealing
Vägverket –Estimation of Road Friction
Novozymes – Agreement on Co-financed PhD study
Emissions Control for Low Climate Impact, KCFP2
Emissions Control for Low Climate Impact, KCFP3
PGS Americas Inc. – Marine Vibrators
ESS – Accelerator Design

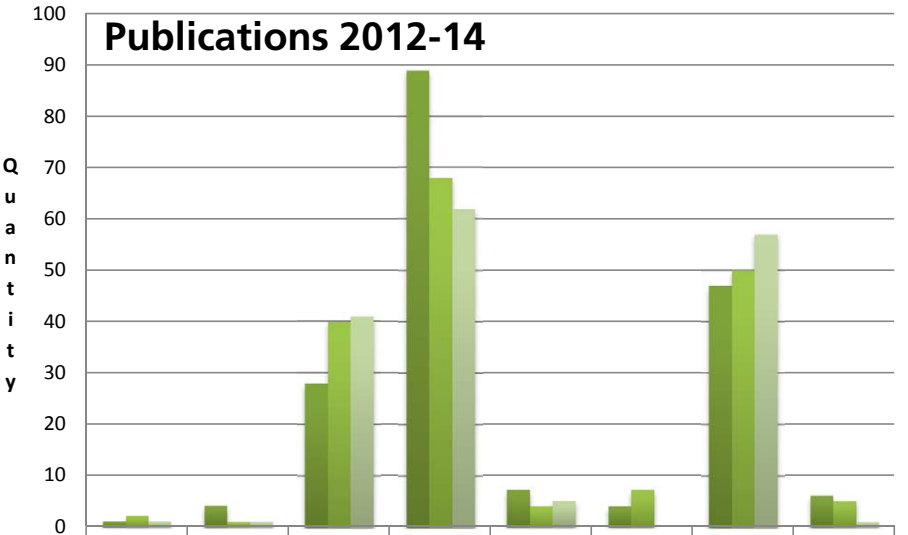
Appendix

This chapter contains a list of Publications, Seminars and Lectures given outside the department during 2014

PUBLICATIONS 2014

You can find references to all the publications on www.control.lth.se/publications and almost all of them can be downloaded from this site. Any of the reports may, however, be borrowed through your library service or from the following libraries in Sweden:

- Linköpings Universitetsbibliotek, Svensktrycket, SE-581 83 Linköping.
- Universitetsbiblioteket Lund, Svenska Tryckavdelningen, Box 1010, SE-221 03 Lund.
- Stockholms Universitetsbibliotek, Box 5039, SE 102 41 Stockholm.
- Umeå Universitetsbibliotek, Box 718, SE-901 01 Umeå.
- Uppsala Universitetsbibliotek, Box 510, SE-751 20 Uppsala.



	Books	Book Contr	Articles	Conf Contr	PhD theses	Lic theses	Master's theses + TM	Techn reports
2012	1	4	28	89	7	4	47	6
2013	2	1	40	68	4	7	50	5
2014	1	1	41	62	5	0	57	1

BOOKS

Giacomo Como, Giacomo; Bernhardsson, Bo; Rantzer, Anders (Eds.); *Information and Control in Networks*, Springer International Publishing, 2014

BOOK CHAPTERS

Giselsson, Pontus; Rantzer, Anders; *Generalized Accelerated Gradient Methods for Distributed MPC Based on Dual Decomposition*; In José M. Maestre, Rudy R. Negenborn (Eds.): Distributed Model Predictive Control Made Easy, Springer Netherlands, 2014.

JOURNAL ARTICLES

Andersen, Martin S.; Khoshfetrat Pakazad, Sina; Hansson, Anders; Rantzer, Anders; *Robust Stability Analysis of Sparsely Interconnected Uncertain Systems;* IEEE Transactions on Automatic Control, 59:8, pp. 2151–2156,2014.

Annaswamy, Anuradha; Callaway, Duncan; Chow, Joseph; DeMarco, Christopher; Hill, David; Khargonekar, Pramod; Rantzer, Anders; Stoustrup, Jakob; *Guest Editorial Special Section on Control Theory and Technology;* IEEE Transactions on Smart Grid, 5:4, pp. 2031–2032,2014.

Åström, Karl Johan; Kumar, P. R.; *Control: A perspective;* Automatica, 50:1, pp. 3–43,2014

Berntorp, Karl; Robertsson, Anders ; Årzén, Karl-Erik; *Rao-Blackwellized Particle Filters with Out-of-Sequence Measurement Processing;* IEEE Transactions on Signal Processing, 62:24, pp. 6454–6467,2014.

Berntorp, Karl; Olofsson, Björn; Lundahl, Kristoffer; Nielsen, Lars; *Models and methodology for optimal trajectory generation in safety-critical road–vehicle manoeuvres;* Vehicle System Dynamics, 52:10, pp. 1304–1332,2014.

Bini, Enrico; Buttazzo, Giuseppe; *The Optimal Sampling Pattern for Linear Control Systems;* IEEE Transactions on Automatic Control, 59:1, pp. 78–90,2014.

Burmyakov, Artem; Bini, Enrico; Tovar, Eduardo; *Compositional Multiprocessor Scheduling: the GMPR interface;* Real-Time Systems, 50:3, pp. 342–376,2014.

Cescon, Marzia; Johansson, Rolf; Renard, Eric ; Maran, Alberto; *Identification of individualised empirical models of carbohydrate and insulin effects on T1DM blood glucose dynamics;* International Journal of Control, 87:7, pp. 1438–1453,2014.

Como, Giacomo; Lovisari, Enrico; Savla, Ketan; *Throughput optimality and overload behavior of dynamical flow networks under monotone distributed routing;* IEEE Transactions on Control of Network Systems, 2014. Accepted for publication.

Garpinger, Olof; Hägglund, Tore; Åström, Karl Johan; *Performance and robustness trade-offs in PID control*; Journal of Process Control, 24:5, pp. 568–577,2014.

Gerber, Tobias; Theorin, Alfred; Johnsson, Charlotta; *Towards a seamless integration between process modeling descriptions at Business and Production levels - work in progress;* Journal of Intelligent Manufacturing, 25:5, pp. 1089–1099,2014.

Giselsson, Pontus; Rantzer, Anders; *On feasibility, stability and performance in distributed model predictive control;* IEEE Transactions on Automatic Control, 59:4, pp. 1031–1036, January 2014.

Hast, Martin; Hägglund, Tore; *Low-order feedforward controllers: Optimal performance and practical considerations;* Journal of Process Control, 24:9, pp. 1462–1471,2014.

Holmqvist, Anders ; Magnusson, Fredrik ; Stenström, Stig; *Scale-up Analysis of Continuous Cross-flow Atomic Layer Deposition Reactor Designs;* Chemical Engineering Science, 117, pp. 301–317,2014.

Holmqvist, Anders; Törndahl, Tobias; Magnusson, Fredrik; Zimmermann, Uwe; Stenström, Stig; *Dynamic parameter estimation of atomic layer deposition kinetics applied to in situ quartz crystal microbalance diagnostics;* Chemical Engineering Science, 111, pp. 15–33,2014

Kharisov, Evgeny; Hovakimyan, Naira; Åström, Karl Johan; *Comparison of architectures and robustness of model reference adaptive controllers and L-1 adaptive controllers;* International Journal of Adaptive Control and Signal Processing, 28:7-8, pp. 633–663,2014.

Khong, Sei Zhen; Tan, Ying; Manzie, Chris ; Nesic, Dragan; *Multi-agent source seeking via discrete-time extremum seeking control;* Automatica, 50:9, pp. 2312–2320,2014.

Khong, Sei Zhen; Cantoni, Michael; *Gap metrics for time-varying linear systems in a continuous-time setting;* Systems & Control Letters, 70, pp. 118–126,2014.

Kirchsteiger, Harald; Johansson, Rolf; Renard, Eric; del Re, Luigi; *Continuous-time interval model identification of blood glucose dynamics for type 1 diabetes;* International Journal of Control, 87:7, pp. 1454–1466,2014.

Kortier, Henk; Antonsson, Jacob; Schepers, Martin; Gustafsson, Fredrik; Veltink, Peter; *Hand pose estimation by fusion of inertial and magnetic sensing aided by a permanent magnet;* IEEE Transactions on Neural Systems and Rehabilitation Engineering, 2014.

Lindholm, Anna; Nytzén, Nils-Petter; *Hierarchical scheduling and disturbance management in the process industry*; Computers & Chemical Engineering, 71, pp. 489–500,2014

Madjidian, Daria; Mirkin, Leonid; *Distributed Control with Low-Rank Coordination;* IEEE Transactions on Control of Network Systems, 1:1, pp. 53–63,2014.

Maggio, Martina; Terraneo, Frederico; Leva, Alberto; *Task scheduling: a control-theoretical viewpoint for a general and flexible solution;* ACM Transactions on Embedded Computing Systems, 13:4, pp. 76–76:22, May 2014.

Mancuso, Guilio M.; Bini, Enrico; Pannocchia, Gabriele; *Optimal Priority Assignment to Control Tasks;* ACM Transactions on Embedded Computing Systems, 13, pp. 161–,2014.

Panerati, Jacopo; Maggio, Martina; Carminati, Matteo; Sironi, Filippo; Triverio, Marco; Domenico Santambrogio, Marco; *Coordination of Independent Loops in Self-Adaptive Systems;* ACM Transactions on Reconfigurable Technology and Systems, 7:2, pp. 12–12:16,2014.

Papadopoulos, Alessandro Vittorio; Leva, Alberto; *Automating efficiency-targeted approximations in modelling and simulation tools: dynamic decoupling and mixed-mode integration;* SIMULATION: Transactions of The Society for Modeling and Simulation International, 90:10, pp. 1158–1176,2014.

Papadopoulos, Alessandro Vittorio; Leva, Alberto; *A model partitioning method based on dynamic decoupling for the efficient simulation of multibody systems*; Multibody System Dynamics, pp. 1–28,2014. Accepted for publication

Pawlowski, Andrzej; Cervin, Anton; Guzmán, José Luis; Berenguel, Manuel; *Generalized Predictive Control With Actuator Deadband for Event-Based Approaches;* IEEE Transactions on Industrial Informatics, 10:1, pp. 523–537,2014.

Perninge, Magnus; *Finding points of maximal loadability considering post-contingency corrective controls;* Electric Power Systems Research, 116, pp. 187–200,2014.

Perninge, Magnus; Söder, Lennart; *Irreversible investments with delayed reaction: an application to generation re-dispatch in power system operation;* Mathematical Methods of Operations Research, 79:2, pp. 195–224,2014.

Perninge, Magnus; *Stochastic optimal power flow by multi-variate Edgeworth expansions;* Electric Power Systems Research, 109, pp. 90–100,2014.

Rodríguez, Carlos; Guzmán, José Luis; Berenguel, Manuel; Hägglund, Tore; *Optimal feedforward compensators for systems with right-half plane zeros;* Journal of Process Control, 24:4, pp. 368–374,2014.

Romero Segovia, Vanessa; Hägglund, Tore ; Åström, Karl Johan; *Measurement noise filtering for common PID tuning rules;* Control Engineering Practice, 32, pp. 43–63,2014.

Romero Segovia, Vanessa; Hägglund, Tore; Åström, Karl Johan; *Measurement noise filtering for PID controllers;* Journal of Process Control, 24:4, pp. 299–313,2014.

Savla, Ketan; Como, Giacomo; Dahleh, Munther A.; *Robust network routing under cascading failures;* IEEE Transactions on Network Science and Engineering, 2014. Accepted for publication.

Schneider, Ulrich; Olofsson, Björn; Sörnmo, Olof; Drust, Manuel; Robertsson, Anders; Hägele, Martin; Johansson, Rolf; *Integrated approach to robotic machining with macro/micro-actuation;* Robotics and Computer-Integrated Manufacturing, 30:6, pp. 636–647,2014.

Son, Hyoung Il; Jung, Hoeryong; Lee, Doo Yong; Cho, Jang Ho; Buelthoff, Heinrich H.; *A psychophysical evaluation of haptic controllers: viscosity perception of soft environments;* Robotica, 32:1, pp. 1–17,2014.

van Heusden, Klaske; Dumont, Guy A.; Soltesz, Kristian; Petersen, Christian L.; Umedaly, Aryannah; West, Nicholas; Ansermino, J. Mark; *Design and clinical evaluation of robust PID control of propofol anesthesia in children;* IEEE Transactions on Control Systems Technology, 22:2, pp. 491–501,2014.

Wallen Axehill, Johanna; Dressler, Isolde; Gunnarsson, Svante; Robertsson, Anders; Norrlöf, Mikael; *Estimation-based ILC applied to a parallel kinematic robot*; Control Engineering Practice, 33, pp. 1–9,2014.

Widd, Anders; Liao, Hsien-Hsin; Gerdes, J. Christian; Tunestål, Per; Johansson, Rolf; *Hybrid Model Predictive Control of Exhaust Recompression HCCI;* Asian Journal of Control, 16:2, pp. 370–381,2014.

Word, Daniel; Kang, Jia; Laird, Carl; Åkesson, Johan; *Efficient Parallel Solution of Large-Scale Nonlinear Dynamic Optimization Problems;* Journal of Computational Optimization and Applications, 59:3, pp. 667–688,2014.

CONFERENCE CONTRIBUTION

Aminifar, Amir; Bini, Enrico; Eles, Petru; Peng, Zebo; *Bandwidth-Efficient Controller-Server Co-Design with Stability Guarantees;* In 2014 Design, Automation and Test in Europe Conference, Dresden, Germany, March 2014.

Bagge Carlson, Fredrik; Vuong, Ngoc Dung; Johansson, Rolf; *Polynomial Reconstruction of 3D sampled Curves Using Auxiliary Surface Data;* In 2014 IEEE International Conference on Robotics and Automation, Hong-Kong, China, June 2014

Berner, Josefin; Åström, Karl Johan; Hägglund, Tore; *Towards a New Generation of Relay Autotuners;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014. Accepted for publication.

Berntorp, Karl; Olofsson, Björn; Robertsson, Anders; *Path Tracking with Obstacle Avoidance for Pseudo-Omnidirectional Mobile Robots Using Convex Optimization;* In 2014 American Control Conference, Portland, Oregon, June 2014.

Berntorp, Karl; Nordh, Jerker; *Rao-Blackwellized Particle Smoothing for Occupancy-Grid Based SLAM Using Low-Cost Sensors;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Brero, Gianluca; Como, Giacomo; Fagnani, Fabio; *Dynamics in network games with local coordination and global congestion effects;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014. Accepted for publication.

Buttazzo, Giorgio C.; Bini, Enrico; Buttle, Darren; *Rate-Adaptive Tasks: Model, Analysis, and Design Issues;* In 2014 Design, Automation and Test in Europe Conference, Dresden, Germany, March 2014.

Cano Marchal, Pablo; Sörnmo, Olof; Olofsson, Björn; Robertsson, Anders;, Gómez Ortega, Juan; Johansson, Rolf; *Iterative Learning Control for Machining with Industrial Robots;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Como, Giacomo; Fagnani, Fabio; *Robustness of large-scale stochastic matrices to localized perturbations;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014. Accepted for publication.

De Coninck, Roel; Magnusson, Fredrik; Åkesson, Johan; Helsen, Lieve; *Grey-Box Building Models for Model Order Reduction and Control;* In 10th International Modelica Conference, Lund, Sweden, March 2014.

Dürango, Jonas; Dellkrantz, Manfred; Maggio, Martina; Klein, Cristian; Papadopoulos, Alessandro Vittorio; Hernández-Rodriguez, Francisco; Elmroth, Erik; Årzén, Karl-Erik; *Control-theoretical load-balancing for cloud applications with brownout;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014.

Epperlein, Jonathan P.; Bamieh, Bassam; Åström, Karl Johan; *Control Laboratory Experiments in ThermoAcoustics Using the Rijke Tube;* In 2014 American Control Conference, Portland, Oregon, June 2014.

Filieri, Antonio; Hoffmann, Henry; Maggio, Martina; *Automated Design of Self-Adaptive Software with Control-Theoretical Formal Guarantees;* In 36th International Conference on Software Engineering (ICSE), Hyderabad, India, May 2014. Accepted for publication.

Fredriksson, Emil; Andersson, Christian; Åkesson, Johan; *Discontinuities handled with events in Assimulo;* In 10th International Modelica Conference, Lund, Sweden, March 2014.

From, Pål Johan; Cho, Jang Ho; Robertsson, Anders; Nakano, Tomohiro; Ghazaei, Mahdi; Johansson, Rolf; *Hybrid Stiff/Compliant Workspace Control for Robotized Minimally Invasive Surgery;* In 5th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics, Sao Paulo, Brazil, August 2014.

Garpinger, Olof; Hägglund, Tore; *Modeling for Optimal PID Design;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014. Accepted for publication

Ghazaei, Mahdi; Cho, Jang Ho; Johansson, Rolf; Robertsson, Anders; *Trajectory Generation for Assembly Tasks Via Bilateral Teleoperation;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Grussler, Christian; Rantzer, Anders; *Modified balanced truncation preserving ellipsoidal cone-invariance;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014

Guzmán, José Luis; Hägglund, Tore; Åström, Karl Johan; Dormido, Sebastián; Berenguel, Manolo; Piquet, Yves; *Understanding PID design through interactive tools;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Hoffmann, Henry; Maggio, Martina; *PCP: A Generalized Approach to Optimizing Performance Under Power Constraints through Resource Management;* In 11th International Conference on Autonomic Computing, Philadelphia, PA, USA, June 2014. Accepted for publication.

Ito, Hiroshi; Rüffer, Björn; Rantzer, Anders; *Max- and Sum-Separable Lyapunov Functions for Monotone Systems and Their Level Sets;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014.

Jonsson, Vanessa; Rantzer, Anders; Murray, Richard M.; *A Scalable Formulation for Engineering Combination Therapies for Evolutionary Dynamics of Disease;* In 2014 American Control Conference, Portland, Oregon, June 2014.

Johnsson, Charlotta; Yang, Qinmin; Nilsson, Carl-Henric; Jin, Jun; Larsson, Andreas; Warell, Anders; *Fostering Automatic Control Students to Become Innovators;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Khong, Sei Zhen; Lovisari, Enrico; *Robust Synchronisation of Heterogeneous Networks Via Integral Quadratic Constraints;* In 22nd Mediterranean Conference on Control and Automation, Palermo, Italy, June 2014.

Khong, Sei Zhen; Lovisari, Enrico; Rantzer, Anders; *Consensus analysis via integral quadratic constraints;* In The 21st International Symposium on Mathematical Theory of Networks and Systems, Groningen, Netherlands, July 2014.

Khong, Sei Zhen; Manzie, Chris; Tan, Ying; Nesic, Dragan; *Multi-agent gradient climbing via extremum seeking control;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Khong, Sei Zhen; Rantzer, Anders; *Scalable stability conditions for heterogeneous networks via integral quadratic constraints;* In 13th European Control Conference, Strasbourg, France, 2014.

Khong, Sei Zhen; *Non-Model Based Finite-Horizon Sampled-Data Optimal Control Via Global Extremum Seeking;* In 2014 IEEE Multi-Conference on Systems and Control, Antibes, France, October 2014.

Klein, Cristian; Maggio, Martina; Årzén, Karl-Erik; Hernández-Rodriguez, Francisco; *Brownout: Building More Robust Cloud Applications;* In 36th International Conference on Software Engineering (ICSE), Hyderabad, India, May 2014. Accepted for publication.

Klein, Cristian; Papadopoulos, Alessandro Vittorio; Dellkrantz, Manfred; Dürango, Jonas; Maggio, Martina; Årzén, Karl-Erik; Hernández-Rodriguez, Francisco; Elmroth, Erik; *Improving Cloud Service Resilience using Brownout-Aware Load-Balancing;* In 33rd IEEE International Symposium on Reliable Distributed Systems, Nara, Japan, October 2014.

Lee, Chih Feng; Khong, Sei Zhen; Frisk, Erik; Krysander, Mattias; *An extremum seeking approach to parameterised loop-shaping control design;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Leva, Alberto; Mastrandrea, Daniele; Bonvini, Marco; Papadopoulos, Alesssandro Vittorio; *Object-Oriented Modelling and Simulation of Air Flow in Data Centres Based on a Quasi-3D Approach for Energy Optimisation;* In 6th Cloud Control Workshop, London, UK, December 2014. Accepted for publication.

Lindholm, Anna; Lidestam, Helene; Quttineh, Nils-Hassan; *Hierarchical Production Scheduling - A Case Study at Perstorp;* In 24th European Symposium on Computer Aided Process Engineering (ESCAPE), Budapest, Hungary, 2014.

Lovisari, Enrico; Como, Giacomo; Savla, Ketan; *Stability of monotone dynamical flow networks;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014. Accepted for publication.

Lundahl, Kristoffer; Olofsson, Björn; Berntorp, Karl; Åslund, Jan; Nielsen, Lars; *Towards Lane-Keeping Electronic Stability Control for Road-Vehicles;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Madjidian, Daria; Mirkin, Leonid; *Distributed Control with Low-Rank Coordination;* In The 21st International Symposium on Mathematical Theory of Networks and Systems, Groningen, Netherlands, July 2014. Accepted for publication.

Madjidian, Daria; *A Decomposition Result in Linear-Quadratic Coordinated Control;* In 19th IFAC World Congress, Cape Town, South Africa, 2014. Accepted for publication.

Madjidian, Daria; Mirkin, Leonid; Rantzer, Anders; *Optimal Coordination of Homogeneous Agents Subject to Delayed Information Exchange;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014. Accepted for publication.

Maggio, Martina; Klein, Cristian; Årzén, Karl-Erik; *Control strategies for predictable brownouts in cloud computing;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014. Accepted for publication.

Magnusson, Fredrik; Berntorp, Karl; Olofsson, Björn; Åkesson, Johan; *Symbolic Transformations of Dynamic Optimization Problems;* In 10th International Modelica Conference, Lund, Sweden, March 2014.

Mannesson, Anders; Bernhardsson, Bo; Yaqoob, Muhammad Atif; Tufvesson, Fredrik; *Optimal Virtual Array Length Under Position Imperfections;* In IEEE 8th Sensor Array and Multichannel Signal Processing Workshop, A Coruña, Spain, June 2014. Accepted for publication.

Nilsson, Gustav; Como, Giacomo; Lovisari, Enrico; *On Resilience of Multicommodity Dynamical Flow Networks;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014. Accepted for publication.

Nordh, Jerker; *Rao-Blackwellized Auxiliary Particle Filters for Mixed Linear/Nonlinear Gaussian models;* In 12th International Conference on Signal Processing, Hangzhou, China, October 2014.

Olofsson, Björn; Sörnmo, Olof; Robertsson, Anders; Johansson, Rolf; *Continuous-Time Gray-Box Identification of Mechanical Systems Using Subspace-Based Identification Methods;* In 2014 IEEE/ASME International Conference on Advanced Intelligent Mechatronics, Besançon, France, July 2014.

Papadopoulos, Alessandro Vittorio; Prandini, Maria; *Model Reduction of Switched Affine Systems: a Method Based on Balanced Truncation and Randomized Optimization;* In 17th International Conference on Hybrid Systems: Computation and Control, Berlin, Germany, April 2014.

Papadopoulos, Alessandro Vittorio; Casella, Francesco; Leva, Alberto; *Model separability indices for efficient dynamic simulation;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014. Accepted for publication.

Papadopoulos, Alessandro Vittorio; Bascetta, Luca; Ferretti, Gianni; *A Comparative Evaluation of Human Motion Planning Policies;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014. Accepted for publication.

Rantzer, Anders; Bernhardsson, Bo; *Control of convex-monotone systems;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014.

Romero Segovia, Vanessa; Hägglund, Tore; Åström, Karl Johan; *Design of measurement noise filters for PID control;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Savla, Ketan; Lovisari, Enrico; Como, Giacomo; *On Maximally Stabilizing Adaptive Signal Control for Urban Traffic Networks under Multi-movement Phase Architecture;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Savla, Ketan; Como, Giacomo; Dahleh, Munther A.; *Robust Oblivious Routing for Network Flows under Cascading Failures;* In 53rd IEEE Conference on Decision and Control, Los Angeles, CA, December 2014. Accepted for publication.

Ståhl, Fredrik; Johansson, Rolf; Renard, Eric; *Intrapersonal variability in post-prandial response based on meal categorization;* In Diabetes Technology Meeting 2013, San Francisco, USA, October 2014. Accepted for publication.

Ståhl, Fredrik; Johansson, Rolf; Renard, Eric; *Investigation of the difference in post-prandial glucose excursion based on meal categorization;* In Diabetes Technology Meeting 2013, San Francisco, USA, October 2014. Accepted for publication.

Stemmann, Meike; Rantzer, Anders; *Temperature control of two interacting rooms with decoupled PI Control;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Stenmark, Maj; Malec, Jacek; Stolt, Andreas; *From High-Level Task Descriptions to Executable Robot Code;* In Intelligent Systems, IS'14, , September 2014.

Terraneo, Federico; Rinaldi, Luigi; Maggio, Martina; Papadopoulos, Alessandro Vittorio; Leva, Alberto; *FLOPSYNC-2: efficient monotonic clock synchronisation;* In 2014 IEEE Real-Time Systems Symposium (RTSS), Rome, Italy, December 2014. Accepted for publication.

Theorin, Alfred; Johnsson, Charlotta; *On Extending JGrafchart with Support for FMI for Co-Simulation;* In 10th International Modelica Conference, Lund, Sweden, March 2014.

Theorin, Alfred; Johnsson, Charlotta; *A Freely Available Interactive PID Learning Module;* In Reglermöte 2014, Linköping, Sweden, June 2014.

Theorin, Alfred; Johnsson, Charlotta; *An Interactive PID Learning Module for Educational Purposes;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

Theorin, Alfred; Hagsund, Johan; Johnsson, Charlotta; *Service Orchestration with OPC UA in a Graphical Control Language;* In 19th IEEE International Conference on Emerging Technologies and Factory Automation, Barcelona, Spain, September 2014.

Yaqoob, Muhammad Atif; Mannesson, Anders; Bernhardsson, Bo; Butt, Naveed; Tufvesson, Fredrik*; On the Performance of Random Antenna Arrays for Direction of Arrival Estimation;* In IEEE ICC 2014 Workshop on Advances in Network Localization and Navigation, Sydney, Australia, June 2014.

Xu, Yang; Årzén, Karl-Erik; Bini, Enrico; Cervin, Anton; *Response Time Driven Design of Control Systems;* In 19th IFAC World Congress, Cape Town, South Africa, August 2014.

PHD THESES

Berntorp, Karl; *Particle Filtering and Optimal Control for Vehicles and Robots;* PhD Thesis ISRN LUTFD2/TFRT--1101--SE, Department of Automatic Control, Lund University, Sweden, May 2014.

Lindberg, Mikael; *From Competitive to Cooperative Resource Management for Cyber-Physical Systems;* PhD Thesis ISRN LUTFD2/TFRT--LUTFD2/TFRT--1102-SE--SE, Department of Automatic Control, Lund University, Sweden, June 2014.

Madjidian, Daria; *Low-Rank Distributed Control with Application to Wind Energy;* PhD Thesis ISRN LUTFD2/TFRT--ISRN LUTFD2*TFRT--1103--SE, Department of Automatic Control, Lund University, Sweden, June 2014.

Romero Segovia, Vanessa; *CPU Resource Management and Noise Filtering for PID Control;* PhD Thesis ISRN LUTFD2/TFRT--1100--SE, Department of Automatic Control, Lund University, Sweden, April 2014.

Theorin, Alfred; *A Sequential Control Language for Industrial Automation;* PhD Thesis Department of Automatic Control, Lund University, Sweden, November 2014.

TECHNICAL REPORTS

Rantzer, Anders; Rasmusson, Monika (Eds.); *Activity Report 2013;* Technical Report ISRN LUTFD2/TFRT--4041--SE, Department of Automatic Control, Lund University, Sweden,2014.

MASTER'S THESES

Alagic, Samir; Nordgren, Viktor; *Control strategy and lifetime optimization of Electrochemical Double-Layer Capacitors;* Master's Thesis ISRN LUTFD2/TFRT--5940--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Andersson, Riccard; *Cool-down and Warm-up of the Cryogenic Distribution Line at ESS;* Master's Thesis ISRN LUTFD2/TFRT--5939--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Andersson, Viktor; Nylander, Tommi; *Simulation of Process Control Network Traffic;* Master's Thesis ISRN LUTFD2/TFRT--5949--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Arlock, Carl Cristian; Linderoth-Olson, Edward; *A Practical Comparison of Scheduling Algorithms for Mixed Criticality Embedded Systems;* Master's Thesis ISRN LUTFD2/TFRT--5959--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Artman, Knut; Jonsson, Eric; *Managing Change in the Warehouse - a structured change management approach when implementing warehouse management systems.* TM.

Asgharian, Arsham; Hatziantoniou, Philip; *Implementing a ZigBee-Based Smart Lighting System;* Master's Thesis ISRN LUTFD2/TFRT--5955--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Bäckström, Adam; *Time-Optimal Control by Iterating Forward and Backward in Time;* Master's Thesis ISRN LUTFD2/TFRT--5944--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Blasco Serrano, Daniel; *Combustion Engine Identification and Control;* Master's Thesis ISRN LUTFD2/TFRT--5943--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Carlson, Adam; Emilsson, Karin; Wennerström, Elin; *Har din organisation en ohälsosam identitet? - fallstudie om identitetsdynamik och organisationshälsa.* TM.

Chakir, Miriam; Lindesvärd, Gabrielle; Svenstrup, Hanna; *Nytt ledarskap - ur mellanchefers perspektiv. En fallstudie på Trafikverket.* TM.

Dahlin, Elin; *Probabilistic Lane Association;* Master's Thesis ISRN LUTFD2/TFRT--5937--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Daun, Thomas; *Iterative Learning Control for Milling with Industrial Robots in Advanced Manufacturing;* Master's Thesis ISRN LUTFD2/TFRT--5942--SE, Department of Automatic Control, Lund University, Sweden, 2014.

De Craene Johansson, Fredrik; Mabrouk, Karim; *Important Market Characteristics in International Establishments.* TM.

Einarsson, Stefan; Melin, Sara; *Samarbete mellan R&D- och marknadsavdelning i Fuzzy Front End för att stödja radikal innovation.* TM.

Engblom, Christer; *Evaluation of Galil DMC-4080 as a Controller of Stewart Platform;* Master's Thesis ISRN LUTFD2/TFRT--5946--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Fredriksson, Johan; Lindberg, Erik; *Kan kvalitéer för lärande organisation tränas i skolsystemet? En fallstudie på Apelgårdsskolan i Rosengård.* TM.

Green, Christian; Lidberg, Pauline; *Approximering av kapitalkrav till följd av namnkoncentrationsrisk inom krediter - En jämförelse mellan två metodiker, Schablonmetoden samt en vald IRK-metod: Granularity Adjustment.* TM.

Hagsund, Johan; *Implementation of Service Orchestrated control procedures in OPC UA for JGrafchart;* Master's Thesis ISRN LUTFD2/TFRT--5953--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Hastig, Sara; Tapper Jansson, Sofie; *Val av energieffektiviserande åtgärder: En fallstudie av fastighetsägarnas investeringsbedömning vid renovering.* TM.

Henriksson, Gustav; Rönnels, Kristoffer; *Faciliteringen av en värdebaserad prissättningsstrategi: Vad hindrar säljstyrkan från att komma ombord?.* TM.

Hugne, Frida; Sörensson, Helena; *Thank you SerVices, How to design a systematic model for service development.* TM.

Johnsson, Fredrik; Svensson, Olle; *Resource Management and Prioritization in an Embedded Linux System;* Master's Thesis ISRN LUTFD2/TFRT--5952--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Kamp, Michaela; Gustafsson, Nina; *1+1 > 2 - Strävan efter framgångsrik radikal innovation genom internt samarbete i FFE.* TM.

Karlsson, Anton; *JTAG-optimisation for CANoe;* Master's Thesis ISRN LUTFD2/TFRT--5945--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Karlsson, Fredrik; Karlsson, Martin; *Sensor Fused Indoor Positioning Using Dual Band WiFi Signal Measurements;* Master's Thesis ISRN LUTFD2/TFRT--5932--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Keskikangas, Axel; Sällberg, Gustav; *Designing and Implementing a Model Vehicle Platoon with Longitudinal Control;* Master's Thesis ISRN LUTFD2/TFRT--5933--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Kyeyune, Karen; *Optimizing Control of a Power System during an Emergency;* Master's Thesis ISRN LUTFD2/TFRT--5960--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Lam, Elisabeth; Meana, Souzan; *Matching companies' CSR efforts with consumers' perceptions.* TM.

Larsson, Johan; *Estimation of dialysis treatment efficiency by means of system identification;* Master's Thesis ISRN LUTFD2/TFRT--5934--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Leonard, Johanna; Kjölstad Svedu, Anna; *Problem Areas Encountered in Creating Valuable Smartphone Software - A Software Product Management Case Study.* TM.

Lilja, Caroline; Sjödahl, Caroline; *Reduced food waste by the use of dynamic shelf life technology?* TM.

Lind, Erik; Meijer, Magnus; *Simulation and Control of Submarines;* Master's Thesis ISRN LUTFD2/TFRT--5954--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Månsson, Christian; Stenberg, Daniel; *Model-based Design Development and Control of a Wind Resistant Multirotor UAV;* Master's Thesis ISRN LUTFD2/TFRT--5947--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Martinsson, Hugo; Roxenheim, Jonathan; Hallström, Thomas; *A Road to Success Under Construction? Examining the Constraints of Public-Private Partnerships in Sweden.* TM.

Millnert, Victor; *Quality-Latency Trade-Off in Bilateral Teleoperation;* Master's Thesis ISRN LUTFD2/TFRT--5951--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Moreno, Carlos Jorques; *Optimization and control of feed and transfer pumps;* Master's Thesis ISRN LUTFD2/TFRT--5956--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Norlin, Fanny; Ahlman, Erik; Manganar, Angelo; *Facilitating Consciousness Development - A Study of a Course in Consciousness.* TM.

Ohlsson, Henrik; Corluka, Hrvoje; *Modellering och reglering av en oktakopter;* Master's Thesis ISRN LUTFD2/TFRT--5935--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Palmkvist, Elias; *Implementation of Grey-Box Identification in JModelica.org;* Master's Thesis ISRN LUTFD2/TFRT--5941--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Persson, Daniel; Wadman, Fredrik; *Self-Playing Labyrinth Game Using Camera and Industrial Control System;* Master's Thesis ISRN LUTFD2/TFRT--5948--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Petersson, Victor; Wideland, Stefan; *Tjänsteinnovation i Samhällsbyggnadsbranschen - En fallstudie för att identifiera nyckelfaktorer i skapandet av innovativa tjänster.* TM.

Rodrigo Marco, Vicent; *Alarm flood reduction using multiple data sources;* Master's Thesis ISRN LUTFD2/TFRT--5961--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Runvik, Håkan; *Modelling and start-up optimization of a coal-fired power plant;* Master's Thesis ISRN LUTFD2/TFRT--5950--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Saryan, Taravat; *Modeling and Observer Design of a Nonlinear LCL Filter for Three-Phase Grid-Connected Voltage Source Converter;* Master's Thesis ISRN LUTFD2/TFRT--5938--SE, Department of Automatic Control, Lund University, Sweden, 2014.

Thiberg, Robin; Gustafsson, Jacob; Nilsson, Per; *Produktportföljshantering, processorientering, sub-strategy alignment.* TM.

SEMINARS AT THE DEPARTMENT

January

17 - Master's Thesis Presentation: *Sensor Fused Indoor Positioning Using Dual Band WiFi Signal Measurements;* Martin Karlsson, Fredrik Karlsson
23 - *Automatic Control for the Process Industry;* Rasmus Olsson, Corebon AB
30 - Master's Thesis Presentation: *Grafchart and OPC UA;* Johan Hagsund

February

18 - *Large-scale Structured Models for Visual Scene Understanding;* Cristian Sminchisescu, Department of Mathematics, Faculty of Engineering, Lund University
20 -Master's Thesis Presentation: *Probabilistic Lane Association with Particle Filter;* Elin Dahlin
25 - *Consensus, communities and centralities for large networks;* Jean-Charles Delvenne, UCLouvain, Belgium

March

7 - *Quo Vadis Building Simulation - New generation computational tools;* Michael Wetter, Lawrence Berkeley National Laboratory, CA, USA
18 - *Identification of contact conditions by active force sensing;* Takayoshi Yamada, Gifu University, Japan
21 - Master's Thesis Presentation: *Cool-down and Warm-up of the Cryogenic Distribution Line at ESS;* Riccard Andersson
21 - *Supporting Self-aware Adaptation from Hardware to Applications;* Henry Hoffmann, Department of Computer Science, University of Chicago, USA

April

2- *Randomized methods for systems and control design in the presence of uncertainty;* Maria Prandini, Politecnico di Milano, Italy
3 - Master's Thesis Presentation: *Modeling and observer design of a nonlinear LCL filter for three phase grid-connected voltage source converter;* Taravat Saryan
3 - *Grasp Stability Analysis of Multiple Objects;* Takayoshi Yamada, Gifu University, Japan
15 - *Consensus-Based Distributed Online Prediction and Optimization;* Michael Rabbat, McGill University, Canada
23 - Defence Of Doctoral Dissertation: *CPU Resource Management and Noise Filtering for PID Control;* Vanessa Romero Segovia, Dept. of Automatic Control, LTH, Lund University
28 - *Open Challenges in QoS Management for Cloud Federation;* Gaetano Anastasi, HPC Laboratory at the National Research Council (CNR) of Italy in Pisa
28 - *Control of Virtualized GPU Resource in Cloud Gaming;* Jianguo Yao, Shanghai Jiao Tong University
29 - Master's Thesis Presentation: *Implementation of Grey-Box Identification in JModelica.org;* Elias Palmkvist
29 - *Resource and Performance Control in Cloud-based Multi-tier Applications;* Olumuyiwa Ibidunmoye, Umeå University
29 - *Testing Elastic Cloud Applications;* Alessio Gambi, Vienna University of Technology, Austria
29 - *Coupling strength allocation for synchronization in complex networks using spectral graph theory;* Ming Cao, University of Groningen, Netherlands

May

5 - *SCHED_DEADLINE: what it does and doesn't do, yet;* Juri Lelli, Scuola Superiore Sant'Anna, Pisa, Italy
6 - *A control approach for guaranteeing performance in Big Data Cloud Systems;* Bogdan Robu, University of Grenoble, France
13 - Master's Thesis Presentation: *Modelling and start-up optimization of a coal-fired power plant;* Håkan Runvik
14 - *CoMoT - a Toolset for Elasticity in the Cloud;* Hong-Linh Truong, TU Wien, Austria
14 - *Understanding Cloud workloads;* Ahmed Ali Eldin Hassan, Umeå University
15 - *Cloud Workload Characterisation;* Amardeep Mehta, Umeå University
15 - *Context-Aware Optimization in Cloud Management;* Jakub Krzywda, Umeå University
19 - *Learning to Coordinate in Social Networks;* Ali Jadbabaie, University of Pennsylvania
20 - *Gaussian mixtures based IRLS: a quadratic rate for sparse signal recovery;* Chiara Ravazzi, Politecnico di Torino, Italy
20 -*Accelerated second order methods for deterministic and stochastic network optimization;* Ali Jadbabaie, University of Pennsylvania
21 - Master's Thesis Presentation: *Control strategy and lifetime optimizaiton of Electrochemical Double-Layer Capacitors;* Samir Alagic; Viktor Nordgren
22 - *Progressive Gaussian Filtering based on Deterministic Sampling;* Uwe D. Hanebeck, Karlsruhe Institute of Technology, Germany
23 - Defence Of Doctoral Dissertation: *Particle Filtering and Optimal Control of Vehicles and Robots;* Karl Berntorp, Dept. of Automatic Control, LTH, Lund University
27 - *Dynamic coupling design for nonlinear output agreement and time-varying flow control;* Claudio De Persis, University of Groningen, Netherlands

June

5 - Master's Thesis Presentation: *Self-Playing Labyrinth Game Using Camera and Industrial Control System;* Daniel Persson; Fredrik Wadman
5 - Master's Thesis Presentation: *JTAG-based Testing Using CANoe;* Anton Karlsson
9 - Defence Of Doctoral Dissertation: *From Competitive to Cooperative Resource Management for Cyber-Physical Systems;* Mikael Lindberg
10 - *Architecture of Complex Control Systems Based on PID Control;* Henry Salomons
10 - *Flexible Time-Triggered Switched Ethernet: Towards Flexible/Open Cyber-Physical Systems;* Luis Almeida, DaRTES lab, Telecommunications Institute, University of Porto, Portugal
12 - Master's Thesis Presentation: *Combustion Engine Identification and Control;* Daniel Blasco
12 - *The role of PID Controllers in Alarm Reduction and Automated Procedures;* Henry Salomons
13 - Master's Thesis Presentation: *Time-optimal control by iterating forward and backward in time;* Adam Bäckström
13 - Defence Of Doctoral Dissertation: *Low-Rank Distributed Control with Application to Wind Energy;* Daria Madjidian
13 - Master's Thesis Presentation: *Simulation of Process Control Network Traffic;* Viktor Andersson; Tommi Nylander
19 - Master's Thesis Presentation: *Design Development and Control of a Wind Resistant Multirotor UAV;* Daniel Stenberg; Christian Månsson
19 - Master's Thesis Presentation: *Control and optimization of transfer and feed pumps;* Carlos Jorques Moreno

19 - Master's Thesis Presentation: *Robot workspace sensing and control with Leap Motion Sensor;* Guillem Solé Bonet
23 - Master's Thesis Presentation: *Implementing a Zigbee-Based Smart Lighting System;* Arsham Asgharian; Philip Hatziantoniou

July
7 - Master's Thesis Presentation: *Resource management and prioritization in an embedded Linux system;* Olle Svensson; Fredrik Johnsson
7 - Master's Thesis Presentation: *Simulation and control of submarines;* Erik Lind; Magnus Meijer

August
1 - Master's Thesis Presentation: *Kinematic and Dynamic robot compensation for Manufacturing;* Alberto Marini
22 - Master's Thesis Presentation: *Alarm flood reduction using multiple data sources;* Vicent Rodrigo Marco
28 - Master's Thesis Presentation: *The quality-latency trade-off in bilateral teleoperation;* Victor Millnert

September
3 - Master's Thesis Presentation: *Implementation of a condition-based maintenance tool for critical components;* Astrid Stenholm
11 -*Parameter identifiability and optimal experimental design: Theory and application on the identification of reaction kinetics in chemical-looping combustion;* George M. Bollas, Department of Chemical & Biomolecular Engineering, University of Connecticut
16 - *Water and Energy - threats and opportunities;* Gustaf Olsson, Industrial Automation, Lund University
17 - *Analysis and control of stochastic reaction networks - Applications to biology;* Corentin Briat, ETH-Zurich, Department of Biosystems Science and Engineering
18 - *Feedback Control of Robotic Friction Stir Welding;* Jeroen De Backer, TWI Technology Centre (Yorkshire, UK)
19 - Master's Thesis Presentation: *A Practical Comparision of Scheduling Algorithms for Mixed Criticality Embedded Systems;* Edward Linderoth-Olson; Carl Christian Arlock
30 - Master's Thesis Presentation: *Robot Control and Computer Vision for Automated Tests and Verification System on Touch Display Products;* Ragnar Wernersson
30 - *Splitting the differential Riccati equation;* Tony Stillfjord, Numerisk Analys LTH
30 - *Robust Stability of Positive Systems: a Convex Characterization;* Marcello Colombino, ETH Zurich

October
2 - *A New Approach to Sequential Rate-Distortion Problems and Applications;* Takashi Tanaka, Massachusetts Institute of Technology
2 - *Stability and power sharing in microgrids;* Johannes Schiffer, TU Berlin
6 - Master's Thesis Presentation: *Optimizing Control of a Power System during an Emergency;* Karen Kyeyune
7 - *Differentially positive systems;* Fulvio Forni, University of Liege
7 - *Submodularity and Controllability in Complex Dynamical Networks;* Tyler Summers, ETH Zurich

9 -*A scalable approach to the design of large networks;* Richard Pates, University of Cambridge
9 - *Bounded Disturbance Amplification for Mass Chains with Passive Interconnection;* Kaoru Yamamoto, University of Cambridge
13 - *Gossip Coverage Control for Robotic Networks: Dynamical Systems on the space of partitions;* Ruggero Carli, Università di Padova
13 - *A Communication/Control Co-design Paradigm for Networked Control Systems;* Wei Chen, Hong Kong University of Science and Technology
14 - *Resilience of natural gas networks during conflicts, crises and disruptions;* Rui Carvalho, University of Cambridge
14 - *New Approaches to Identification and Control of Nonlinear Systems;* Ian Manchester, University of Sydney
21 - *On the push-sum algorithm with unreliable communication;* Balázs Gerencsér, Université Catholique de Louvain
21 - *Resilience and Cascading Failures in Large-Scale Networks;* Wilbert Rossi, Politecnico di Torino
23 - *Universal Convexification via Risk Aversion;* Dvijotham Krishnamurthy, CalTech
23 - *Distributed and Event-Based State Estimation;* Sebastian Trimpe, Max Planck Institute for Intelligent Systems, Tuebingen
28 - *Stability of Linear Consensus Processes;* Ji Liu, University of Illinois at Urbana Champain
28 - *Control of Evolutionary Games on Networks;* James R. Riehl, University of Groningen

November
14 - Defence Of Doctoral Dissertation: *A Sequential Control Language for Industrial Automation;* Alfred Theorin, Dept. of Automatic Control, LTH, Lund University
20 - *Distributed Learning in Collaborative Control and Decision Making;* John S. Baras, The Institute for Systems Research, University of Maryland College Park, USA

December
18 - Master's Thesis Presentation: *Automatisk reglering av färgen i en pappersmaskin;* Per Johnsson

LECTURES BY STAFF OUTSIDE THE DEPARTMENT

Årzén, Karl-Erik

Management of CPU Resources - From Embedded to the Cloud; Keynote at the 9th IEEE International Symposium on Industrial Embedded Systems, Pisa, Italy, June 19, 2014.

Rao-Blackwellized Particle Smoothing for Occupancy-Grid Based SLAM Using Low-Cost Sensors; IFAC World Congress, Cape Town, South Africa, August 28, 2014.

Åström, Karl Johan

Modeling and Simulation - from Physics to Languages and Software;. Collège de France, Paris, March 19, 2014.

Accomplishments and Prospects of Control; Invited Plenary Lecture. Workshop on Automatic Control for Engineers University of Almeria, March 27, 2014.

Lectures on Foundations of Control; Carrier, Montluel, June 16-19, 2014.

Reflections on Control and Dynamical Systems. CDS'20 Caltech, Pasadena, Aug 6, 2014.

Revisiting the Hidden Technology; Invited Plenary Lecture. Journadas de AUTOMATICA, Valencia, Sept 5, 2014.

Recent advances in PID control; Workshop on Interactivity in Control Education, UNED Madrid, Sept 9, 2014.

Control Design for a MEMS Acclerometer with Tunneling Sensing; 2nd Swedish-Israel Control Conference, Technion, Haifa, Nov 10, 2014.

Control - A Perspective; 2nd Swedish-Israel Control Conference, Technion, Haifa, Nov 11, 2014.

Reglerteknik, matematik och cykling (Control, mathematics and bicycling); Sonja Kovalevsky dagarna, Lund, Nov 15, 2014.

Como, Giacomo

PhD course *Network Dynamics* taught at the Dutch Institute for Systems and Control (DISC), Utrecht, Netherlands, November 17-December 8, 2014

Mini-course *Harmonic influence in Large-Scale Networks* taught at the 21st MTNS Symposium, Groningen, Netherlands, July 7, 2014

Different talks on the theme *Resilient Distributed Control of Dynamical Flow Networks* at the below listed seminars: University of Twente, (Enschede, Netherlands), December 5, 2014; Systems and Control Center, University of Groningen (Netherlands), December 2, 2014; Technion (Haifa, Israel), November 11, 2014; Boston University (Boston, MA, USA), October 28, 2014; LCCC Workshop (Lund, Sweden), October 17, 2014; Istituto Superiore Sant'Anna, (Pisa, Italy), September 23, 2014; Polytechnic of Grenoble, (Grenoble, France), September 15, 2014; Linköping University, (Linköping Sweden), September 11, 2014; IMT Institute for Advanced Studies, (Lucca, Italy), July 15, 2014; University of Austin, (Austin, TX, USA), June 16, 2014; Gran Sasso Science Institute, (L'Aquila, Italy), May 22, 2014**.**

Garpinger, Olof

Modeling for Optimal PID Design.; 19th IFAC World Congress, Cape Town, South Africa, August 27, 2014.

Hägglund, Tore

Signal Filtering in PID Control;. University of Almeria, Spain, March 27, 2014.

Johansson, Rolf

Industrial Robots, Skills and Work-Space Sensing—Recent Trends and Advances in Industrial Robotics; 2014 RoSEC Winter School, RoSEC (Robotics Specialized Education Consortium) & Hanyang University, Seoul, Korea, 8 January 2014. Invited Lecture.

Robotic Work-Space Sensor Fusion and Control; The 8th International Workshop on Innovation and Commercialization of Micro & Nanotechnology (ICMAN2014), Suzhou, Jiangsu, China, 11 November 2014. Invited Lecture.

Robotic Work-Space Sensor Fusion and Control; University of Science and Technology Beijing (USTB), School of Automation & Electrical Engineering, Beijing, China,14 November 2014. Invited Lecture.

Johnsson, Charlotta

From zero to prototype in six weeks –an international cross-disciplinary course on innovation, invited presentation at STINT Forum on China Cooperation – the next phase, organized by STINT (The Swedish Foundation for International Cooperation in Research and Higher Education), Lund, Sweden, 2014-06-13.

An holistic approach to Entrepreneurship, invited presentation at Guangdong University of Finance, Guangzhou, China, 2014-10-17.

From zero to prototype in six weeks, the iMDE course, invited presentation at Guangdong University of Finance, Guangzhou, China, 2014-10-17.

Introduction to Berkeley Method of Entrepreneurship" invited presentation at Guangdong University of Finance, Guangzhou, China, 2014-10-18.

Maggio, Martina

FLOPSYNC-2: efficient monotonic clock synchronisation; Invited to Scuola Superiore Sant'Anna, Real-Time Systems Laboratory, Pisa, Italy, September 2014.

Brownout: building more robust cloud applications; Invited to Politecnico di Milano, Dipartamento di Elettronica, Informazione e Bioingegneria, Milan, Italy, June 2014

Control strategies for predictable brownouts in cloud computing; Conference talk: Martina Maggio, Cristian Klein, and Karl-Erik Årzén, IFAC World Congress 2014.

Khong, Sei Zhen

Robustness analysis via integral quadratic constraints: from feedback to large-scale systems; Division of Automatic Control, Department of Electrical Engineering, Linköping University, Linköping, Sweden, February 27th, 2014.

Distributed robustness analysis of heterogeneous networks via integral quadratic constraints; Division of Optimization and Systems Theory, Department of Mathematics, Royal Institute of Technology (KTH), Stockholm, Sweden, May 5th, 2014.

Rantzer, Anders

Scalable Robustness Analysis Using Integral Quadratic Constraints; Groningen University, Sweden, February 14, 2014.

Scalable Control of Monotone Systems; Invited lecture in the Booz Allen Hamilton Distinguished Colloquium Series, University of Maryland, USA, May 2, 2014.

Scalable Analysis and Control of Monotone Systems; Semi-plenary lecture at 21st International Symposium on Mathematical Theory of Networks and Systems (MTNS 2014), Groningen, The Netherlands, July 9, 2014.

Robustness, Networks, Scalability. Lund - Caltech Interaction for 20+ Years; Invited lecture at the 20th anniversary the Control and Dynamical Systems (CDS) program at Caltech, August 7, 2014

Scalable Robustness Analysis Using Integral Quadratic Constraints; Lecture in the MnDRIVE Seminar Series in Control and Robotics at University of Minnesota, August 14, 2014.

Robust control revisited: A quest for scalability; Invited lecture at the workshop Robustness in Identification, Control and Beyond, Siena, Italy, September 26, 2014.

Scalable Control of Monotone Systems; Plenary Lecture at International Conference on Network Games, Control and Optimization (NetGCoop 2014), Trento, Italy, October 30, 2014.

Control of convex-monotone systems; 53rd Conference on Decision and Control, Los Angeles, USA, December 16, 2014.

Optimal Coordination of Homogeneous Agents Subject to Delayed Information Exchange; 53rd Conference on Decision and Control, Los Angeles, USA, December 17, 2014.

Robertsson, Anders

Styr- och Reglerteknik; lärarfortbildning "Lärarlyftet för Tekniklärare", presentation samt deltagande i Arduino-lab, February 26, 2014.

Robotar och andra svårstyrda saker, Natur-, Medicin- och Teknikdagarna på LTH, Reglerteknik, March 3, 2014.

Reglerteknik och robotar, Teknikåttan, April 10, 2014.

Robotik; lärarfortbildning "Lärarlyftet för Tekniklärare" på Vattenhallen, LTH, April 28, 2014.

SMErobotics och PRACE Automatica fair, Munich, Germany, Collaborative machining, June 3-6, 2014.

Styr- och reglerteknik + arduinoövning, lärarfortbildning "Lärarlyftet för Tekniklärare" på Vattenhallen, October 1, 2014.

Vad är reglerteknik, Gästföreläsning "Datorer i system", November 12, 2014.

During the weekend November 29-30 the nao-robot was demonstrated and a 130 headed public was given the opportunity to program simple robots to draw images on a flat whiteboard at Vattenhallen Science Center.

Westin, Eva

Varför så få kvinnor på LTH? presentation av rapport från kursen "Män, kvinnor och teknik - genuspsykologiska aspekter i undervisningen", LTHs ledningsgrupp, Lund, April 2, 2014.

Wittenmark, Björn

Reglerteknik – Den dolda tekniken (Automatic Control – The hidden technology), Tekniska föreningen, Kristianstad, September 16, 2014.

POPULAR SIENCE PRESENTATIONS

Johnsson, Charlotta

Tummen upp för hierarkisk produktionsplanering; an article in Kemivärlden Nr9, September 2014.

Det behövs mer engagemang i industrin; an article in Process Nordic, October 2014.