Activity Report 2023

AUTOMATIC CONTROL | LUND UNIVERSITY

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Department of Automatic Control
P O Box 118, 221 00 Lund, Sweden
www.control.lth.se

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LUND
UNIVERSITY

Department of Automatic Control

MAILING ADDRESS
Department of Automatic Control
Lund University
P.O. Box 118
SE-221 00 LUND, Sweden

VISITING ADDRESS
Department of Automatic Control
Ole Römers väg 1
223 63 LUND

TELEPHONE
+46 46 222 87 87

WWW AND GENERIC E-MAIL ADDRESS
www.control.lth.se
control@control.lth.se

Edited by Monika Rasmusson and Emma Tegling

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Content

Introduction

A summary of the activities at the Department of Automatic Control, Lund University during the period January 1 to December 31, 2023

Anders Robertsson - in memoriam

July 1967 - April 2023

On April 15th we were informed about the decease of our beloved friend and colleague Anders Robertsson who passed away late afternoon on Friday April 14th after a long struggle against cancer.

Anders joined the department as a PhD student in 1993, after finishing his engineering degree and spending a year at UC Santa Barbara. He quickly became involved in the emerging robotics group under the supervision of Rolf Johansson and was further inspired by several visits to University of Twente. After his PhD dissertation in 1999, he continued as research associate, assistant professor and eventually full professor, soon taking a leading role in establishing the LTH RobotLab.

His research on sensor-based motion control of robots had a big scientific impact, and industrial impact through his active collaborations outside academia. Anders' research together with colleagues led the creation of the spin-off company Cognibotics AB, where he was one of the founders and

board members during the build-up phase. His broad research interests were also reflected in the fact that he was one of the pioneers in control theory for web servers and computing systems.

Anders was deeply interested in teaching. The courses he taught quickly became popular and he became a very popular MSc thesis supervisor. Inspired by his research enthusiasm and creativity, several of the students also chose to continue with research studies under his supervision, which led to a total of nine PhD theses where he was the main or co-supervisor. Anders also had a very active commitment to tell about his research through popular science lectures and tours of the lab. Thousands of schoolchildren have visited the LTH RobotLab during the annual European Robotics Week over the past decade, where Anders enthusiastically and pedagogically explained how robots work, always with illustrative experiments.

Anders was widely known for his characteristically helpful and genuinely curious manner. Always interested in other people and learning new things, he generously shared his time, knowledge and broad contact network with others. This led both to infinitely many happy moments of conversation when he moved around the university campus and also to numerous pleasant trips on skis or cross-country skates during winter days with family, friends, colleagues and visiting researchers.

Anders will be remembered by many people, all over the world, as a distinctive individual; first and foremost an exceptional human being, kind and generous, a spiritual person of integrity and uncompromising values; a talented teacher and great mentor to his numerous students and researchers; a supportive and stimulating colleague; a beautiful mind and an exceptional researcher. The department dearly misses Anders Robertsson as a colleague, supervisor and not least a true friend. He leaves a big void behind him and is deeply missed by his colleagues at Reglerteknik, within LTH RobotLab and at Cognibotics. His memory will live on through his scientific contribution during a rich research career, and to an equal degree through the students and employees whom Anders has supported, over the yeras, and been a highly valued supervisor and role model for.


MASKINTEKNIK
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AUTOMATIC CONTROL HIGHLIGHTS OF 2023

Despite the loss of our dear colleague Anders Robertsson, good things have happended during 2023. In breif this can be summerized as follows.

We are back! Finally, in May, it was time to move back to the renovated M-building after having spent three years located at Kemicentrum. Refurbished offices and, for our department, better co-location of our offices on the premises were highly appreciated when resettled in the M-building. Many of us have contributed to making the move as smooth as possible. A special thanks goes to Tore Hägglund, Anders Blomdell and Eva Westin for their exceptional efforts, and for planning everything in detail with the support of the TA group.

The department now has 57 members (excluding guests and teaching assistants). This year 6 new PhD students, 1 new industrial PHD student, and 2 postdocs joined the department.

During 2023, the department gave 18 different courses and 1081 students passed, 47 students presented their masters' theses at the department. Four PhD courses were also given.

Two PhD theses were defended and five licentiate theses were presented during 2023. The total number of PhDs graduated from the department is now 142. The number of WASP-funded PhDs and postdocs at the department has again increased, and is now 17. This includes 3 industrial PhD students and two postdocs. Some of our other PhD students are also "WASP affiliated", which means that they can take courses offered within the WASP Graduate School programme. Recently organized study trips have also been added to the programme, as Boston in September.

During 2023, AI tools and, in particular Large Language Models like ChatGPT, were introduced at a large scale globally. They offer many opportunities in both research and education, and also impact our teaching. To mark the advent of these tools, several figures throughout this report have been generated using the AI tool DALL-E.

The by now well established euRobotics week took place during three days in late November. The department of Computer Science and also the Cognition RoboticsLab took part in this event, all under the umbrella of AI Lund.

To increase reasearch visibility, research efforts at Lund University and the Faculty of Engineering have been subdivided into profile areas. The department is involved in several, both at faculty and university level. To futher improve visibility, we have produced several short videos connected to our research and research life. During 2023 we have introduced "Robotics", "Autonomous real-time systems" as well as "Being a PhD student". On the subject *Histrorical Female Influencers*, we have added some new portraits to the collection.

In 2023 the Faculty of Engineering at Lund University had three honorary doctorates. One of them was Professor Ikhlaq Sidhu who has a long and prosperous collaboration with Professor Charlotta Johnsson.

We are also proud to host a Ukranian researcher at the department and thanks to new funding he will be able to extend his stay.

Election of Head and Deputy Head of the Department was performed in late 2023. We are glad to annonce that Karl-Erik Årzén has accepted the position as Head of the Department and Emma Tegling as Deputy Head, starting January 1, 2024.

Even though the Agency Capital decreased by 1 MSEK, the economy is stable and for 2023 showed a turnover of 65 MSEK.

In the future we will depend on new funding to develop and explore new solutions within our field of research.

Monika Rasmusson and Emma Tegling

Education

Education at undergraduate and graduate level including dissertations 2023

UNDERGRADUATE STUDIES

The engineering education at LTH (Faculty of Engineering at Lund University) follows the European educational system with five-year programs leading up to the university degree "civilingenjör", with the international title MSc in engineering.

Automatic control courses are taught as part of the engineering curricula in Engineering Physics (F), Electrical Engineering (E), Computer Engineering (D), Mechanical Engineering (M), Environmental Engineering (W), Engineering Mathematics (Pi), Industrial Management and Engineering (I), Biotechnology (B), Engineering Nanoscience (N), Chemical Engineering (K), and Biomedical Engineering (BME). Our advanced courses are included in more than fifteen of the master-level specializations in the various programs.

During 2023, there were 1468 course registrations and 1081 passed grades were awarded, which corresponds to 184 full-year equivalents. The table on the next page, lists our undergraduate courses, along with the number of students who passed each course. Some of our courses became so popular that we unfortunately had to restrict the number of students, due to lack of staff resources limited availability of lab processes and computational infrastructure. 47 students completed their master's thesis projects, and a total of 33 theses were presented. A list of the master's theses is given in the *Publications and Seminars* chapter.

The two-year international master programme *Machine Learning Systems and Control* was started in 2020. The programme is managed by Mikael Nilsson at the mathematics department and Bo Bernhardsson. In 2023 a fourth batch of 13 students was admitted.

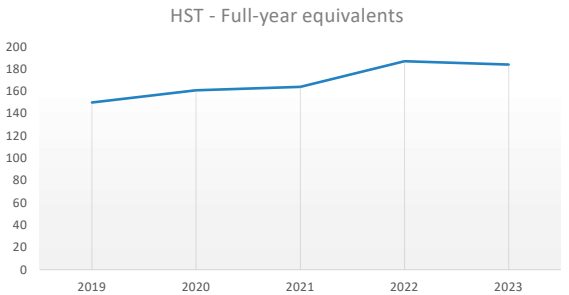
Most of our lectures have now been recorded and we have also developed new formats of teaching which are worthy to maintain also in the future, when we now have returned to a more normal post-pandemic situation.

Many of the courses now have course material available via a Canvas page open to the public.

CHATGPT

During the past year, several persons at the department have begun using AI tools, primarily ChatGPT, as part of their work. Usage largely includes handling text and generating code, but also recalling and discussing aspects of technical topics relevant to automatic control.

An attempt at the beginning of 2023 to use ChatGPT to solve one of our exams failed, but attempts at the beginning of 2024 show that the tool has become much more competent at common problems in automatic control. Following up on the topic of exams, we plan to conduct experiments where research subjects (students) take sample exams without having taken our courses, but are allowed to use ChatGPT (they are not given credits for a passed exam!).



Development over the last five years of full-year equivalents

TOTAL NUMBER OF STUDENTS WHO PASSED OUR COURSES 2023

Automatic Control, Basic Course
(FRTF05 Reglerteknik) 425
Systems Engineering
(FRTF10 Systemteknik)..... 62
Control Theory
(FRTF15 Reglerteori)..... 16
Physiological Models and Computations
(FRTF01 Fysiologiska modeller och beräkningar)..... 64
Nonlinear Control and Servo Systems
(FRTN05 Olinjär reglering och servosystem)..... 25
Real-Time Systems
(FRTN01 Realtidssystem) 47
Automatic Process Control
(FRTN25 Processreglering).....21
Network Dynamics
(FRTN30 Nätverksdynamik) 38
Project in Automatic Control
(FRTN40 Projekt i reglerteknik)..... 22
Mathematical Modeling, Advanced Course
(FRTN45 Matematisk modellering, fortsättningskurs) 46
Optimization for Learning
(FRTN50 Optimering för maskininlärning)..... 25
Automatic Control, Advanced course
(FRTN55 Reglerteknik, fortsättningskurs)..... 79
Real-Time Systems
(FRTN60 Realtidssystem) 4
Modeling and Learning from Data
(FRTN65 Modellering och inlärning från data) 70
Project in Systems, Control and Machine Learning
(FRTN70 Projekt i system, reglering och maskininlärning) 9
Learning-Based Control
(FRTN75 Inlärningsbaserad reglering) 40
Applied Robotics for Architectures
(FRTN80 Tillämpad robotik för arkitekter)..... 4
Applied Robotics
(FRTN85 Tillämpad robotik)..... 37
Degree Project in Automatic Control
(FRTM01 Examensarbete i reglerteknik) 47

COLLABORATION WITH X-LAB

In 2023, Automatic Control and LTH's co-creation and innovation space, X-lab, collaborated to offer a hands-on introduction to PID control in two courses: Automatic Control, Basic Course (FRTF05, lead by Emma Tegling) and Introduction to Machine Learning, Systems and Control (FRTF25, lead by Johan Eker), with Harry Pigot representing X-Lab. In FRTF25, the students built a simple ball-and-beam process as a team-building exercise, then used it as a platform for experimenting with embedded control systems by programming a PID controller on an Arduino microcontroller. The same platform was offered as an extra-curricular opportunity for students in the Basic Course, where they could apply the concepts introduced during lectures to a real system from the ground up. Students from other faculties were also invited to participate. The event was appreciated by attendees, and we plan to further integrate the activity into future courses.

Above: Students in the Master programme Machine Learning Systems and Control. They are in the X-Lab workhop building a ball-on-beam process.

GRADUATE STUDIES

The PhD education consists of four years of studies, but 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". The general syllabus for PhD studies in Automatic Control states that the course requirement for a PhD degree is 90 credits, while the thesis scope is 150 credits.

In 2023 two doctoral theses were defended by Nils Vreman and Albin Heimerson. Five licentiate theses were presented by Julian Salt Ducaju, Felix Agner, Jonas Hansson, Frida Heskebeck and Johan Lindberg. During the year we have admitted Max Nilsson, Anton Åkerman, Yde Sinnema, Talitha Nauta, Ahmed Al Bayati and Emil Sundström as new PhD students and Peter Stoltenberg as industrial PhD student.

The following PhD courses were given at the department in 2023:

- *Causal Inference and Control*; Søren Wengel Mogensen
- *Convex Optimization*; Julia Adlercreutz (examiner Pontus Giselsson)
- *Optimal Control*; Dongjun Wu, Björn Olofsson, Karl Johan Åström
- *Pragmatic Programming*; Max Nilsson (examinner Pontus Giselsson)

Charlotta was involved as a guest speaker in the following PhD courses in 2023:

- *Research methods, ethics and innovation (EDA035F)*
- *Innovation and Value Creation in Research (INT001F)*

There are also several PhD courses organised within the WASP Graduate School programme, available for both WASP graduate and affiliated students. WASP Graduate School students are required to take WASP courses corresponding to at least 27 credits, including the mandatory course and at least 2 out of the 3 foundational courses. See below offered courses:

Mandatory course	*Legal, Ethical and Societal Aspects of AI and Autonomous Systems*
Foundational courses	*Autonomous Systems*
	AI and Machine Learing
	Software Engineering and Cloud Computing
Elective courses	*Deep Learning for Natural Language Processing*
	Deep Learning
	Graphical Models, Bayesian Learning and Statistical Relational Learning
	Interaction, Collaboration and Visualization
	Learning Feature Representations
	Learning Theory
	Reinforcement Learning
	Scalable Data Science and Distributed Machine Learning
	Topological Data analysis
	WASP project course
Introductory courses	*Introduction to logic for AI*
(not included in 27 credits)	*Mathematics for Machine Learning*

HIGHLIGHT: WASP STUDY TRIP TO BOSTON

The WASP Graduate School, to which many of our PhD students belong, organizes international study trips every year. Their goal is to expand the international networks for new PhD students, and expand their perspectives on the WASP-related research areas (AI, Autonomous Systems, and Software). The intention is that every PhD student should join two trips during the first two years of their studies. In September 2023, Emma Tegling and Karl-Erik Årzén from the department organized one such week-long trip to Boston, where each led a group of 17 PhD students, visiting companies and universities in the Boston area.

Karl-Erik's group visited the Robotics Lab at Harvard University, Renato Mancuso's group at the Computer Science Department at Boston University, Boston Dynamics, Mathworks, Mitsubishi Electric Research Labs (MERL), PTC, and Motional. Emma's group also visited the Robotics Lab at Harvard University, Harvard Medical School, Verizon Innovation Labs, Northeastern University, The Robotics Lab and the Hariri Institute at Boston University, Recorded Future, and Munther Dahleh's group at LIDS/IDSS at MIT. During the last day both groups visited MIT where a WASP poster session was held in the LIDS (Laboratory for Information and Decision Systems) lounge. The trip included a WASP Celebratory Dinner and a sailing trip on the Boston Harbor with the boat Liberty Star under blue skies. Everyone stayed at the Hyatt Regency in Downtown Boston.

The trip was very appreciated by the students. Most appreciated was the visit to Boston Dynamics where the student were allowed into the development lab where 70-80 Spot autonomous robot dogs were being tested and trained. They also saw all the historical Boston Dynamics robots in their museum. However, the students also enjoyed the academic visits, where they got a chance to see how graduate students at some of the top reserach institutions in the world worked and formulated their problems. Our hosts really appreciated the initiated questions from our students, and were impressed by the quality and scope of the WASP Graduate School.

DOCTORAL DISSERTATIONS

This year two PhD students defended their theses. The abstracts are presented below.

Nils Vreman Albin Heimerson

ANALYSIS OF EMBEDDED CONTROLLERS SUBJECT TO COMPUTATIONAL OVERRUNS

Nils Vreman

ISBN 978-91-8039-688-2

Microcontrollers have become an integral part of modern everyday embedded systems, such as smart bikes, cars, and drones. Typically, microcontrollers operate under real-time constraints, which require the timely execution of programs on the resource-constrained hardware. As embedded systems are becoming increasingly more complex, microcontrollers run the risk of violating their timing constraints, i.e., overrunning the program deadlines. Breaking these constraints can cause severe damage to both the embedded system and the humans interacting with the device. Therefore, it is crucial to analyse embedded systems properly to ensure that they do not pose any significant danger if the microcontroller overruns a few deadlines.

However, there are very few tools available for assessing the safety and performance of embedded control systems when considering the implementation of the microcontroller. This thesis aims to fill this gap in the literature by presenting five papers on the analysis of embedded controllers subject to computational overruns. Details about the real-time operating system's implementation are included into the analysis, such as what happens to the controller's internal state representation when the timing constraints are violated. The contribution includes theoretical and computational tools for analysing the embedded system's stability, performance, and real-time properties.

The embedded controller is analysed under three different types of timing violations: blackout events (when no control computation is completed during long periods), weakly-hard constraints (when the number of deadline overruns is constrained over a window), and stochastic overruns (when violations of timing constraints are governed by a probabilistic process). These scenarios are combined with different implementation policies to reduce the gap between the analysis and its practical applicability. The analyses are further validated with a comprehensive experimental campaign performed on both a set of physical processes and multiple simulations.

In conclusion, the findings of this thesis reveal that the effect deadline overruns have on the embedded system heavily depends the implementation details and the system's dynamics. Additionally, the stability analysis of embedded controllers subject to deadline overruns is typically conservative, implying that additional insights can be gained by also analysing the system's performance.

LEARNING TO CONTROL THE CLOUD

Albin Heimerson

ISBN 978-91-8039-841-1

With the growth of the cloud industry in recent years, the energy consumption of the underlying infrastructure is a major concern. The need for energy efficient resource management and control in the cloud becomes increasingly important as one part of the solution, where the other is to reduce the energy consumption of the hardware itself.

Resource management in the cloud is typically done using relatively simple methods, with either local controllers or human operators, though as the complexity of the system increases, the need for more intelligent and automated controllers increases as well. The cloud is a complex environment with many individual consumers sharing large pools of resources, scaling and moving their applications to satisfy their own objectives and requirements, while the cloud provider manages the underlying infrastructure to make efficient use of the hardware. This creates a dynamic environment with a highly variable load, and managing efficient resource usage while keeping the quality of service at an acceptable level is a complex task for such unpredictable environments. Both the consumers scaling their resources and the providers managing their infrastructure could benefit from intelligent automation.

By creating control strategies that take a larger context into account, it could allow for more informed decisions, and thus better control. A larger context makes the problem space more complex, and manually designing a controller becomes increasingly difficult. With the abundance of data available in many cloud systems, a data-driven approach seems like a natural choice. Reinforcement learning is a type of machine learning that is well suited for sequential decisions over time, and has been shown to be able to learn complex control strategies in many different domains. We explore the benefits and challenges of applying reinforcement learning methods to control different cloud systems according to complex objectives, and what usability concerns that show up in practice.

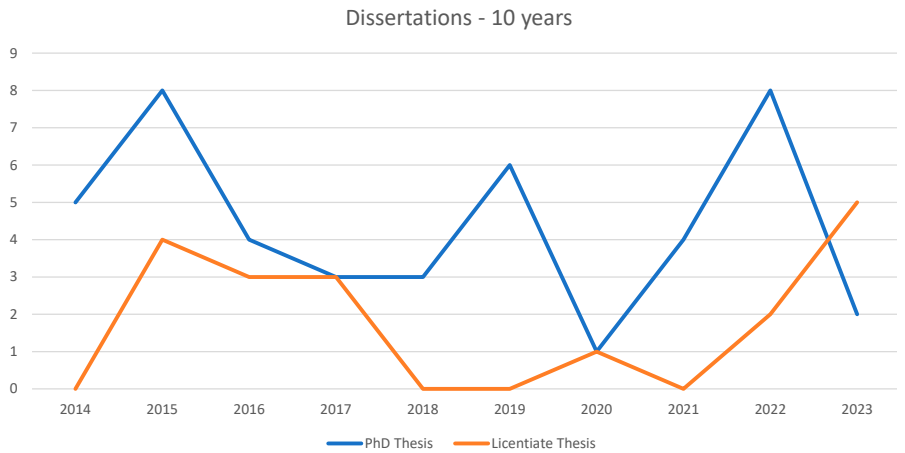
Starting off, we explore the combined control of cooling systems and load balancing in a datacenter. Cooling is a major energy consumer in datacenters, giving us a natural objective for optimization, and the load balancing will affect the heat distribution in the datacenter, thus affecting the cooling. In a simple simulated environment, we apply reinforcement learning to control a mix of discrete and continuous control variables over both cooling and load balancing, with the objective to reduce energy consumption while adhering to temperature thresholds for the servers. We find that the controller is able to learn how to efficiently use the cooling system, improving on a baseline implemented using standard methods. Scaling this up and adding a more realistic air-flow simulation, we find that the gain from perfect placement is so small that it is simply generating noise in comparison to other factors in the cooling system. Instead, we focus on controlling the cooling system with the larger observational context, showing that it outperforms existing standard methods while also being able to adapt to changes in the system.

We then look at the problem of scaling a web services in a cloud environment, where a service is built from many interconnected microservices. These are typically scaled using local reactive controllers, but employing a proactive controller should improve the performance. By providing a reinforcement learning agent with a view over all the services, it implicitly learns how different jobs traverse the system, and use this to proactively scale services, keeping less resources in reserve, and still meeting response time requirements.

Moving from model-free control, we turn to using an existing fluid model of a microservice to create a controller. The fluid model is used to simulate trajectories for a load balancing controller, and

using arbitrary loss functions over the trajectory, we can optimize the parameters of the controller using automatic differentiation. The resulting controller behaves well, though we only take a single gradient step to ensure stable updates, since the accuracy of the fluid model is reduced as the system moves away from the training data. We then show how an imperfect model can be extended with neural networks to capture unmodelled dynamics. For the fluid model, the increased accuracy from the extended model allows for more steps and thus faster policy convergence.

While we find that RL can indeed be used to create policies that improve on standard control methods, there are several usability concerns that arise when applying these methods to real systems. The main issue is the instability of the whole process, from exploration during training driving the system to bad states, to opaque function approximators making it difficult to ensure that the controller behaves as expected when deployed. While we discuss several methods to mitigate these issues, what actually works is highly dependent on the specific system and the requirements on the controller.



10 year period showing the number of dissertations including both doctoral and licentiate thesis

LICENTIATE DISSERTATIONS

This year there were five PhD students presenting their licentiate thesis. The abstracts are presented below.

Julian Salt Ducaju

Felix Agner

Jonas Hansson

Frida Heskebeck

Johan Lindberg

HUMAN-ROBOT COLLABORATION FOR KINESTHETIC TEACHING

Julian Salt Ducaju

Recent industrial interest in producing smaller volumes of products in shorter time frames, in contrast to mass production in previous decades, motivated the introduction of human–robot collaboration (HRC) in industrial settings, as an attempt to increase flexibility in manufacturing applications by incorporating human intelligence and dexterity to these processes. This thesis presents methods for improving the involvement of human operators in industrial settings where robots are present, with a particular focus on kinesthetic teaching, i.e., manually guiding the robot to define or correct its motion, since it can facilitate non-expert robot programming.

To increase flexibility in the manufacturing industry implies a loss of a fixed structure of the industrial environment, which increases the uncertainties in the shared workspace between humans and robots. Two methods have been proposed in this thesis to mitigate such uncertainty. First, null-space motion was used to increase the accuracy of kinesthetic teaching by reducing the joint static friction, or stiction, without altering the execution of the robotic task. This was possible since robots used in HRC, i.e., collaborative robots, are often designed with additional degrees of freedom (DOFs) for a greater dexterity. Second, to perform effective corrections of the motion of the robot through

kinesthetic teaching in partially-unknown industrial environments, a fast identification of the source of robot–environment contact is necessary. Fast contact detection and classification methods in literature were evaluated, extended, and modified to use them in kinesthetic teaching applications for an assembly task. For this, collaborative robots that are made compliant with respect to their external forces/torques (as an active safety mechanism) were used, and only embedded sensors of the robot were considered.

Moreover, safety is a major concern when robotic motion occurs in an inherently uncertain scenario, especially if humans are present. Therefore, an online variation of the compliant behavior of the robot during its manual guidance by a human operator was proposed to avoid undesired parts of the workspace of the robot. The proposed method used safety control barrier functions (SCBFs) that considered the rigid-body dynamics of the robot, and the method's stability was guaranteed using a passivity-based energy-storage formulation that includes a strict Lyapunov function.

All presented methods were tested experimentally on a real collaborative robot

ON HYDRAULIC CONSTRAINTS IN CONTROL OF DISTRICT HEATING SYSTEMS
Felix Agner

District heating systems make an important puzzle piece in the energy system of both today and tomorrow. When designing, simulating and controlling these systems, hydraulics play a vital role. The pressure generated by pumps has to drive sufficient flow throughout the system to satisfy the requirements of customers. Ensuring that the system is sufficiently pressurized is a challenging task already in current systems, and may become even more challenging in the transition to the 4th generation of district heating.

In the first paper of this thesis, a demand response framework is suggested, which distributes the available flow to customers in a fair way. The framework aims to make it so that when the available pressure in the network is low, the buildings in the periphery should still be able to satisfy their heating needs.

The second paper of this thesis extends previous methods for identifying greybox parameters for hydraulic district heating models. Previous methods of this type rely on more measurement points, and do not include the influence of the control valves situated in customer substations. These model parameters can then be used for simulation or control purposes.

Together, the results presented in this thesis provide tools for better dealing with the hydraulic limitations in district heating systems. At the end, future work is outlined which may further pave the way for improved control that takes hydraulic limitations into account.

TRANSIENT ANALYSIS AND CONTROL FOR SCALABLE NETWORK SYSTEMS
Jonas Hansson

The rapidly evolving domain of network systems poses complex challenges, especially when considering scalability and transient behaviors. This thesis aims to address these challenges by offering insights into the transient analysis and control design tailored for large-scale network systems. The thesis consists of three papers, each of which contributes to the overarching goal of this work.

The first paper, A closed-loop design for scalable high-order consensus, studies the coordination of nth-order integrators in a networked setting. The paper introduces a novel closed-loop dynamic named serial consensus, which is designed to achieve consensus in a scalable manner and is shown to be implementable through localized relative feedback. In the paper, it is shown that the serial

consensus system will be stable under a mild condition — that the underlying network contains a spanning tree — thereby mitigating a previously known scale fragility. Robustness against both model and feedback uncertainties is also discussed.

The second paper, Closed-loop design for scalable performance of vehicular formations, expands on the theory on the serial consensus system for the special case when n=2, which is of special interest in the context of vehicular formations. Here, it is shown that the serial consensus system can also be used to give guarantees on the worst-case transient behavior of the closed-loop system. The potential of achieving string stability through the use of serial consensus is explored.

The third paper, Input-output pseudospectral bounds for transient analysis of networked and high-order systems, presents a novel approach to transient analysis of networked systems. Bounds on the matrix exponential, coming from the theory on pseudospectra, are adapted to an input-output setting. The results are shown to be useful for high-order matrix differential equations, offering a new perspective on the transient behavior of high-order networked systems.

ON CALIBRATION ALGORITHMS FOR REAL-TIME BRAIN-COMPUTER INTERFACES

Frida Heskebeck

A Brain-Computer Interface (BCI) is a system that, in real-time, translates the user's brain activity into commands that can be used to control applications, such as moving a cursor on the screen. The translation is made possible by machine learning methods and other algorithms. The thesis focuses on EEG-based BCIs which are the most common type of BCIs due to EEG measurements being non-invasive, having good temporal resolution, and being suitable for many applications. As of today, one of the biggest challenges for BCIs is the so-called calibration, which is necessary for the BCI to translate the user's brain activity correctly. The need for calibration comes from the variability of the brain signals over time and between users.

This thesis presents an extensive review of the state-of-the-art algorithms for BCIs, focusing on the calibration problem. Amongst the presented algorithms are methods for processing the EEG data, machine learning algorithms, and a brief introduction to transfer learning and Riemannian geometry. A more in-depth exploration of the so-called multi-armed bandits and Markov decision processes as possible methods to streamline the calibration procedure is presented, as well as a real-time framework for gathering and testing algorithms. Such a framework is crucial for testing new approaches for efficient calibration.

ON H2 AND H-INFINITY OPTIMAL CONTROL OF MASS-SPRING NETWORKS WITH POWER SYSTEM APPLICATIONS

Johan Lindberg

Electric power systems are undergoing huge changes due to the shift from conventional power production to more renewable-based generation like solar and wind. This is primarily driven by the need to mitigate climate change by reducing CO2 emissions. The shift to more generation from solar and wind will affect the dynamical behaviour of power systems, and consequently how they should be controlled. This thesis explores optimal control with respect to disturbance rejection. The systems that are investigated are damped mass-spring systems. The dynamics of AC frequency in power systems can be captured through such models. Further, the implications of the derived optimal control laws are investigated.

In the first paper of this thesis, undamped mass-spring systems (and more generally lossless systems) are investigated. The optimal controllers that achieve the lowest H2-gain and H∞-gain from disturbances to performance outputs are derived analytically for a standard setup. An analytical expression of the optimal gains are also presented. Finally, the results are interpreted in the context of electrical power systems. The results show the detrimental effect low inertia, typically associated with renewable generation like solar and wind, can have on H2 performance. However, it is further shown numerically that under the optimal controller, these effects are mostly isolated to the low inertia regions of the grid.

The second paper of this thesis considers H2 optimal control for disturbance rejection for a damped mass-spring system with uniform damping. The main contribution is to show that the optimal controller that achieves the smallest gain from disturbances to performance outputs is itself a damped mass-spring system. The optimal controller works both for stable and unstable systems. In the unstable case the H2-gain becomes larger than the undamped system in the first paper, while for positively damped systems it becomes smaller.

Together the results presented in this thesis offer optimal controllers for un-damped and uniformly damped mass-spring systems. These have been applied to simple models of electrical power transmission. Finally, future work detailing how to extend the techniques to cover a broader range of power system control problems is outlined.

Research

This chapter presents our excellence centers and describes our three main research branches and their ongoing projects

EXCELLENCE CENTERS AND NATIONAL PROJECTS

ELLIIT – The Linköping–Lund Initiative on IT and mobile communication
HI2OT – Nordic University Hub on Industrial Internet of Things
WASP – Wallenberg AI, Autonomous Systems and Software Program

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

Funding: Government-funded Strategic Research Area

ELLIIT is a strategic research environment funded by the Swedish government in 2010, as part of its initiative to support strong research in information technology and mobile communications.

ELLIIT has four partners: Linköping University, Lund University, Halmstad University and Blekinge Institute of Technology.

ELLIIT constitutes a platform for both fundamental and applied research, and for cross-fertilization between disciplines and between academic researchers and industry experts. ELLIIT stands out by the quality and visibility of its publications, and its ability to attract and retain top talented researchers and aims at being recognized as a top international research organization.

ELLIIT achieves its goals by a judicious choice of funded focus projects, a structured process for international recruitment, a balanced way of stimulating cooperation between research areas and between the sites involved (LiU, LU, BTH, HH), and a proactive approach towards fostering and maintaining cooperation with Swedish industry. The overarching objective of ELLIIT is to support scientific excellence in combination with industrial relevance and impact.

In the 2020 national budget bill for University Research and Education, an additional 72 MSEK/year were allocated to the strategic research area in IT and mobile communication with a focus on digitalization, i.e., an increase of the original budget with close to 200%. This initiated a major restart of ELLIIT including a new organization and restructuring of the research programme.

During 2023, ELLIIT organized two focus periods. One on *Network Dynamics and Control* in Linköping Sep 4 – Oct 6 and one on *6G – forming a better future* in Lund Oct 23 – Nov 24. The focus periods unite young international scholars, ELLIIT researchers and other top international academics active in the relevant domains.

During 2023, ELLIIT also produced 12 ELLIIT Tech Talks on digitalization and societal challenges from an ICT perspective. The well-known Swedish research communicator and comedian Johan Wester was the moderator, see https://elliit.se/education-outreach/elliit-tech-talks/

HI2OT – NORDIC UNIVERSITY HUB ON INDUSTRIAL INTERNET OF THINGS

Reseachers: Årzén, Karl-Erik; Maggio, Martina; Eker, Johan

Partners: DTU – Technical University of Denmark, Lund University, KTH – Royal Institute of Technology, NTNU – Norwegian University of Science and Technology, Aalto University

Funding: Nordforsk - Nordic University Hubs

The overall aim of HI2OT is to promote Nordic collaboration in Industrial Internet of Things (IIoT), which will increase the capacity of the participating organizations and create the critical mass needed to establish a world-leading Nordic research environment on IIoT.

There will soon be 50 billion "smart things" worldwide. When these become interconnected they form the Internet of Things, IoT. Industrial IoT (IIoT) is providing the infrastructure that underpins our Smart Society (Smart Energy Grid, Smart Cities, Smart and Green Mobility, Smart Manufacturing, etc.).

The Nordic University (H)ub on (I)ndustrial (IoT) (HI2OT) is focused on Industrial IoT, a Nordic area of growth and a key technology enabler in solutions to several societal challenges. IIoT will only become a reality through the convergence of Operational and Information Technologies (OT & IT), which are currently separated. This will require multidisciplinary large-scale research effort. Hence, HI2OT brings together the strongest Nordic research groups in IIoT (8 groups at 5 universities) to form a long-term partnership for expanding IIoT cooperation in the Nordic region.

The overall aim of HI2OT is to promote Nordic collaboration in IIoT, which will increase the capacity of the participating organizations and create the critical mass needed to establish a world-leading Nordic research environment on IIoT. HI2OT provides a unique integration of expertise, generating the synergies required to support the convergence of IT and OT. HI2OT builds a platform and a community to strengthen and structure the IIoT research and innovation. This will enhance strengthen national research and innovation systems by increasing their capacity and increase the ability of Nordic nations to address European and global cooperation and competition in IIoT, as well as increasing their competitiveness and growth via research and innovation.

Funding: Knut and Alice Wallenberg Foundation (KAW)

Wallenberg AI, Autonomous Systems and Software Program (WASP) is Sweden's largest individual research program ever, and provides a platform for academic research and education, fostering interaction with Sweden's leading technology companies. The program addresses research on autonomous systems acting in collaboration with humans, adapting to their environment through sensors, information, and knowledge, and forming intelligent systems-of-systems. Software is the main enabler in autonomous systems and is an integrated research theme of the program. WASP's key values are research excellence and industrial relevance.

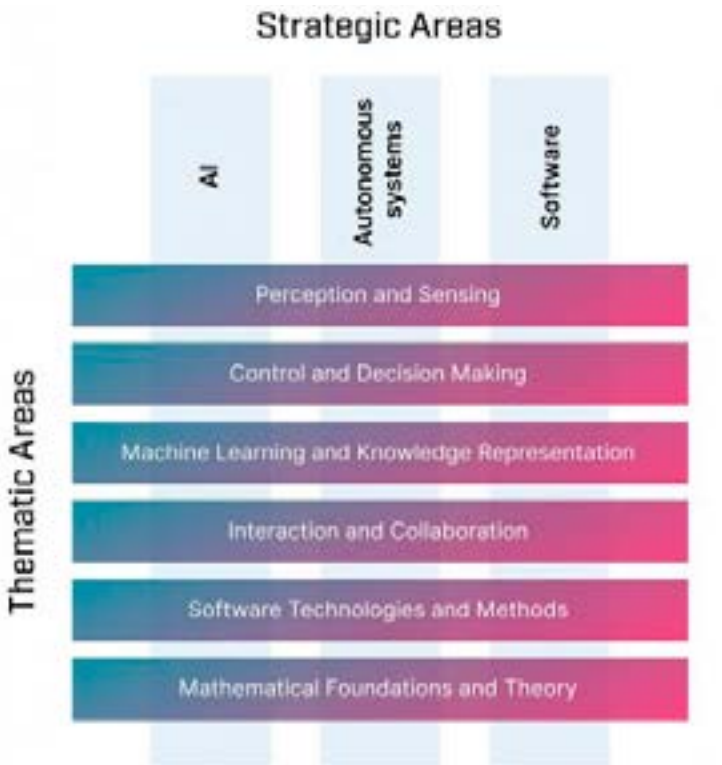
WASP is funded by the Knut and Alice Wallenberg Foundation with co-funding from industry and the involved universities. The program, which started in 2015, will continue until 2031 with a total budget of SEK 6.2 billion.

The graduate school within WASP is dedicated to providing the skills needed to analyze, develop, and contribute to the interdisciplinary area of AI, autonomous systems and software. The curriculum provides the foundations, perspectives, and state-of-the-art knowledge in the different disciplines taught by leading researchers in the field. Through an ambitious program with research visits, partner universities, and visiting lecturers, the graduate school actively supports forming a strong multi-disciplinary and international professional network between PhD-students, researchers, and industry. The graduate school provides added value on top of the existing PhD programs at the partner universities, providing unique opportunities for students who are dedicated to achieving international research excellence with industrial relevance.

WASP involves eight Swedish universities together with numerous Swedish industries. At Lund University the following four departments participate: Department of Automatic Control, Department of Computer Science, Department of Electrical and Information Technology, and the Mathematical Imaging Group at the Department of Mathematics.

Oct 4 to Oct 6 2023, the first Wallenberg Advanced Scientific Forum was held. The topic was AI Scientists, i.e., AI systems capable of making Nobel-quality scientific discoveries highly autonomously at a level comparable, and possibly superior to the best human scientists by 2050. At the beginning of 2024 WASP funds the following positions at our department: 14 academic PhD students, 3 industrial PhD students (with Saab Kockums, Boliden, and Ericsson), 8 affiliated PhD students (funded from other sources), 1 associate professor (Emma Tegling), and 2 postdocs.

Karl-Erik Årzén (WASP Co-director for Research Program Coordination since beginning 2021) and Anders Rantzer are involved in the management of WASP and Monika Rasmusson is the WASP Financial Officer for Lund University.



The research in WASP can be illustrated as a matrix with two dimensions, a strategic dimension and a thematic dimension. The strategic dimension emphasizes areas of impact on individuals, society, and industry, whereas the thematic areas represent the underlying scientific and technological challenges that are common to all types of autonomous systems. The research is conducted at seven Swedish universities: Chalmers University of Technology, KTH Royal Institute of Technology, Linköping University, Lund University, Umeå University, Örebro University, and Uppsala University.

LUND UNIVERSITY AND FACULTY OF ENGINEERING PROFILE AREAS

During 2022 both Lund University and its Faculty of Engineering (LTH) concluded an open call for profile areas. Constellations of senior researchers submitted proposals of research areas in which the university/faculty are particularly strong and visible. The department of Automatic Control is involved in serveral of the profile areas.

Out of the five Lund University profile areas - Automatic Control is involved in one of them, namely *Natural and Artificial Cognition*. Read more about Lund University profile areas at https://www.lunduniversity.lu.se/research-and-innovation/research-excellence-areas/profile-areas.

NATURAL AND ARTIFICIAL COGNITION

This profile area will extend our understanding of behavioral patterns of natural and artificial systems and develops new artificial cognitive abilities in software and systems. Cognition means how humans, animals and machines perceive, receive, process, store, retrieve and share information.

During 2023 the Faculty of Engineering profile areas where extended by another two namely, *Water* and *Food and Bio*. Read more about the Faculty's profile areas at https://www.lth.se/english/research/profile-areas/. The ones mentioned below include members from Automatic Control.

ENGINEERING HEALTH

Contributes to improving human health and solving challenges in healthcare by developing and providing new tools for diagnostics, treatments, and home care solutions.

AI AND DIGITALIZATION

AI and digitalization are a rapidly growing part of the development of almost all engineering systems and will fundamentally change society and industry.

THE ENERGY TRANSITION

This Area develops technical solutions together with academic partners across the world including the local research facilities ESS and Max IV. Equally important is to introduce the solutions through collaboration with industry and authorities, where the national competence centres form important networks.

RESEARCH BRANCHES

The goal of the department is to provide students with a solid theoretical foundation combined with a good engineering ability. This is reflected in its research program, which covers both theory and applications. Automatic control, mathematics, and computer science form the core of all our research. To make our research more visible we have during 2023, continued to produce short films to be found on the department webpage about our different research areas.

The research activities can roughly be divided into three thematic branches:

LARGE-SCALE SYSTEMS AND LEARNING

What do traffic networks, wind farms, Facebook and economic markets have in common? They are all large-scale networked systems, which can be analyzed and optimized using automatic control techniques.

AUTONOMOUS REAL-TIME SYSTEMS

Their vision? To create user-friendly, self-adaptive, resilient, high-performing systems, with low latency and jitter, while being cost-effective.

INNOVATIVE CONTROL APPLICATIONS

This is a branch of application-driven research motivated by the desire to create a more sustainable society. It addresses several of the UN's 17 Sustainable Development Goals.

LARGE SCALE SYSTEMS AND LEARNING

What do traffic networks, wind farms, Facebook and economic markets have in common? They are all large-scale networked systems, which can be analyzed and optimized using automatic control techniques. By developing scalable methods for control and optimization, researchers at the Department of Automatic Control are contributing to solving one of the greatest challenges in modern engineering - the sustainable and safe operation of these large-scale systems.

A significant part of this field of research is directed towards developing theories and methodologies supporting the design and verification of distributed control structures. Other important parts focus on combining classical physics-based models with machine-learning tools, and combining models for traditional networks, for example, for electricity and heating, with learning algorithms for consumer behavior and decision-making. The aim is to improve efficiency and reliability, while at the same time reducing costs.

Ongoing projects:

- Scalable Control of Interconnected Systems (ERC)
- Learning in Networks; Structure, Dynamics and Control
- Dynamics, Information and Control in Networks
- Scalable Control Using Learning and Adaptation
- Dynamics of Complex Socio-Technological Network Systems
- Learning and Adaptation
- Scalable Control for Increased Flexibility in District Heating Networks
- Statistical and Adversarial Learning in Continuous System Control
- Throughput Control in Autonomous Networks
- Performance, Controllability, and Robustness of Large-Scale and Non-Normal Network Systems
- Large-Scale Optimization
- Scalable Optimization for Control Systems
- Optimal estimation and control at scale
- Visual analytics of large and complex multilayer technological networks
- Bregman optimization algorithms
- Model Predictive Control Stability Analysis
- Automatic Luaponov Analysis of Optimazation Algorithms

SCALABLE CONTROL OF INTERCONNECTED SYSTEMS

Researchers: Rantzer, Anders; Pates, Richard; Agner, Felix; Grönqvist, Johan; Kjellqvist, Olle; Renganathan, Venkatraman; Wu, Dongjun

Funding: European Research Council - ERC Advanced Grant

Modern society is critically dependent on large-scale networks for services such as energy supply, transportation and communications. The design and control of such networks is becoming increasingly complex, due to their growing size, heterogeneity and autonomy. A systematic theory and methodology for control of large-scale interconnected systems is therefore needed. In an ambitious effort towards this goal, this project will address the following key aspects:

- Modeling by leveraging tools from learning and adaption
- Control design by utilizing structural properties of the system
- Verification of system performance using decomposable certificates

Energy networks will be used as a guiding example for the development of theory and methodology. Close collaboration with industrial partners will ensure that the research is relevant and useful in practice.

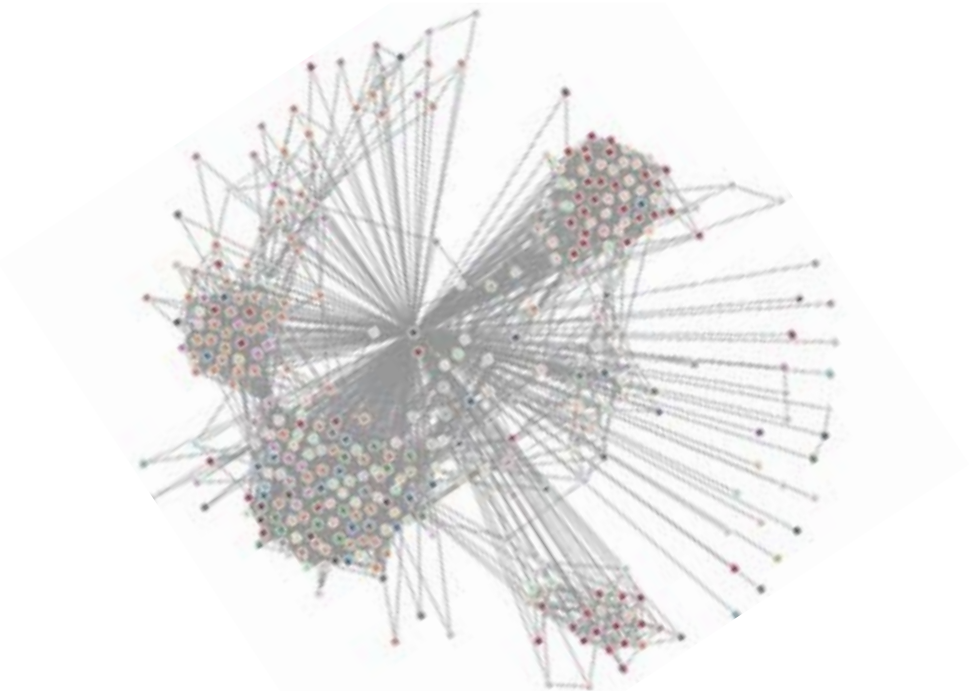
LEARNING IN NETWORKS: STRUCTURE, DYNAMICS, AND CONTROL (WASP NEST)

Researchers: Proutiere, Alexandre (KTH); Tegling, Emma; Rantzer, Anders; Skerman, Fiona (UU); Gurpegui Ramón, Alba; Hansson, Jonas; Bencherki, Fethi; Ohlin, David; Jeeninga, Mark

Funding: WASP

Many complex systems, whether biological, physical, social, or economical, are structured in networks consisting of a large collection of interacting entities. Some of these networks, such as social networks on the Internet emerge without our control or intervention. As a consequence, their structure, the way their entities interact and evolve are a priori unknown. Some are designed and deployed by engineers, but their scale may become so large (this is for instance the case of future mobile networks) that their individual entities cannot be finely tuned when deployed, and again the structure of the network and the interactions between its entities cannot be predicted. Our ability to optimize the operation of a network, however, strongly relies on an accurate knowledge of its characteristics.

In this project, we will develop novel mathematical and computational tools to devise efficient algorithms learning the network structure and dynamics, as well as efficient ways to control it. This vast and ambitious objective calls for a multidisciplinary effort, and we envision to reach it leveraging and combining techniques from probability theory, statistical machine learning, and control theory.



DYNAMICS, INFORMATION AND CONTROL IN NETWORKS

Researchers: Pates, Richard; Como, Giacomo; Rantzer, Anders; Tegling, Emma

Funding: ERC, VR

Large-scale networks play a constantly increasing role in our modern society, e.g., affecting the access to essential services like mobility and energy, influencing the outcome of electoral polls, and determining the quality of the economic systems.

The Department hosts a research group on Dynamics, Information, and Control in Networks. The focus of this group is on the mathematical foundations of large-scale network systems with particular emphasis on issues related to their resilience, centrality, and scalability. Applications include cyber-physical systems, transportation networks, as well as social and economic networks.

One project is focused on transportation networks, with publications about decentralized traffic signal control and distributed dynamic tolls.

Another project studies the interplay between economics and traffic flows in transport networks. We will study exchange equilibria in traffic networks and network dynamics in presence of human decision makers. The goal is to gain deeper understanding of, and be able to exploit, the interaction between node demands and network flows.

SCALABLE CONTROL USING LEARNING AND ADAPTATION

Researchers: Kjellqvist, Olle; Rantzer, Anders; Bernhardsson, Bo

Funding: ERC

At the United Nations Summit 2015, our world leaders adopted 17 Sustainable Development Goals. A necessary condition for the completion of these goals is efficient, reliable, and safe infrastructure. For example, Goal 7: Affordable and Clean Energy requires infrastructure robust to loss of the inertia prevalent in conventional power plants, such as coal, gas, and nuclear power. As the nature of consumption and production changes, the networks' structures and underlying control mechanisms must keep up. Unfortunately, many of the anticipated changes increase the load and introduce additional complexity. Examples are micro-producers of electricity, autonomous vehicles in transportation networks, and increased nodes in communication networks. As complexity can increase by orders of magnitude, controlling these networks requires models at an entirely new scale. Manually sustaining accurate models of individual components becomes infeasible. A solution is to use adaptation and learning to automatically learn and sustain models, taking care to do so in a reliable and scalable way.

In the doctoral studies, he addresses the fundamentals of scalable modeling's technical challenges using adaptation and learning. He study minimax control and graph realizability of controllers, meaning controllers that respect information exchange constraints in networks. The aim is to synthesize algorithms for scalable, robust adaptive control that automatically sustains accurate models of highly complex networks. Such algorithms can facilitate the complex technologies and infrastructures needed to reach the Sustainable Development Goals.

DYNAMICS OF COMPLEX SOCIO-TECHNOLOGICAL NETWORK SYSTEMS

Researchers: Tegling, Emma; Como, Giacomo; Ohlin, David; Bencherki, Fethi; Altafini, Claudio (LiU); Bakovic, Luka; Jeeninga, Mark

Funding: ELLIIT

We investigate how opinions and beliefs propagate on social networks, i.e., on networks of individuals interacting over socio-technological media. We use data and dynamical models in order to understand the mechanisms by which sociologically relevant macroscopic collective behaviors, such as opinion polarization, can emerge from microscopic (i.e., individual-level) interactions.

LEARNING AND ADAPTATION

Researchers: Grönqvist, Johan; Kjellqvist, Olle; Heskebeck, Frida; Bernhardsson, Bo; Rantzer, Anders

Funding: ERC and WASP

There are many important applications where classical physics based models need to be combined with machine learning tools. A good example is in autonomous driving, where automotive industry have extensive experience of control technology such as ABS braking, cruise control and ESP systems for vehicle stabilization. This technology now needs to be combined with machine learning methods to analyze traffic situations and human behavior. To do this in a safe and robust manner, it is essential to understand how learning algorithms for discrete sequential decision-making can interact with continuous physics based dynamics. Many other applications can be found. In the energy sector, well established control solutions for power networks and generators are increasingly being combined with learning algorithms for consumer behavior and decision-making, to minimize costs and optimize efficiency. In medicine, standard practice for disease therapies is combined with expert systems and sequential decision-making for medical diagnosis.

In our collaboration project with Alexandre Proutiere at KTH the aim is to bridge the gap between machine learning and control engineering. These research fields have traditionally evolved more or less separately, but in recent years the intersections in terms of applications as well theoretical challenges have been growing. This project is concerned with sequential decision making in systems whose dynamics are initially unknown, i.e., with adaptive control or reinforcement learning. Statistical models are of fundamental importance in both areas, but while learning theory has been focused on sample complexity and regret, the corresponding control literature is discussing stability robustness and asymptotic performance. An important focus of our project is the tradeoff between exploration and exploitation, sometimes known as ”dual control”. The optimal tradeoff strategy can be formulated as the solution to a dynamic programming problem. We study properties of the solution as well as computational schemes. Optimal strategies are compared with common heuristics, both in control and reinforcement learning.

SCALABLE CONTROL FOR INCREASED FLEXIBILITY IN DISTRICT HEATING NETWORKS

Researchers: Agner, Felix; Rantzer, Anders; Pates, Richard

Funding: ERC

This project investigates the development and application of scalable control strategies to explore the flexibility of large scale district heating networks. In particular, we aim to leverage theoretical tools from the field of control theory with a specific focus on those developed for positive systems. The objective is improving the operation of district heating networks while taking into account their limited communication architecture and the need for scalability to large network structures. These control strategies will be employed in demand response and load control architectures that can allow heating networks explore increased flexibility through e.g. demand response and direct load control.

STATISTICAL AND ADVERSARIAL LEARNING IN CONTINUOUS SYSTEM CONTROL

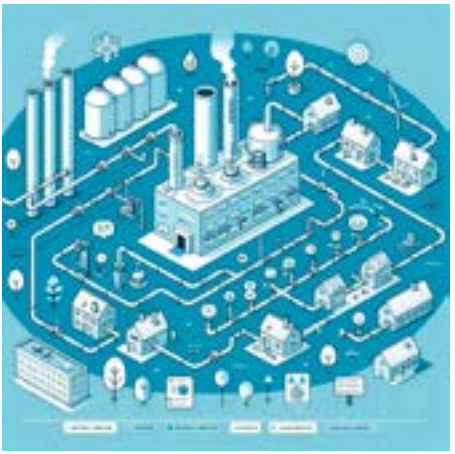
Researchers: Grönqvist, Johan; Kjellqvist, Olle; Rantzer, Anders

Funding: ERC and WASP

This project aims to bridge the gap between machine learning and control engineering. These research fields have traditionally evolved more or less separately, but in recent years the intersections in terms of applications as well theoretical challenges have been growing. This project is concerned with sequential decision making in systems whose dynamics are initially unknown, i.e., with adaptive control or Reinforcement Learning (RL) when using the control engineering and machine learning terminologies, respectively.

We will work on problems where disturbances are assumed to be of worst-case nature. In control theory, this assumption is the basis for H•infinity optimal control, which was introduced in the 1980s to counteract the fact that optimization in a statistical setting often gives poor robustness to unmodeled dynamics.

Inspired by the theory for robust control, based on worst-case assumptions, we would like to develop a theory to make RL or adaptive control algorithms robust to unmodeled dynamics.



THROUGHPUT CONTROL IN AUTONOMOUS NETWORKS

Researchers: Vladu, Emil; Rantzer, Anders; Pates, Richard

Funding: ERC

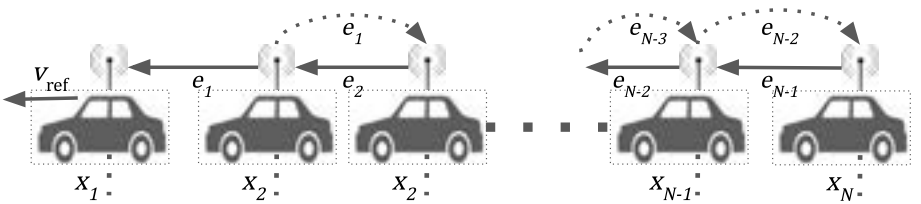
In many areas of application, it is important to suppress the impact of disturbances and model uncertanties on the desired output behavior. Large-scale systems in particular benefit additionally from transparent and sparse controllers. In this research, we are interested in sparse controller structures which give rise to optimal or near-optimal worst-case disturbance attenuation. The research output thus far considers linear as well as nonlinear systems, and positive systems in particular.

PERFORMANCE, CONTROLLABILITY, AND ROBUSTNESS OF LARGE-SCALE AND NON-NORMAL NETWORK SYSTEMS

Researchers: Tegling, Emma; Hansson, Jonas

Funding: WASP

Characterizing the dynamic behaviors of interconnected systems is an important and to large extents open research problem. For example, it is important to understand how the structural properties of a network impact how well it can be controlled, and how robust it is to disturbances and model errors



LARGE SCALE OPTIMIZATION

Researchers: Giselsson, Pontus; Banert, Sebastian; Upadhyaya, Manu

Funding: VR and WASP

Optimization is a modeling tool that has been used in many engineering fields for a long time. It can be used, e.g., for optimal control, financial decision making, signal reconstruction, route planning, statistical estimation, and training of supervised learning machines. Different optimization problems have different properties and fall into different categories. They can be coarsely divided into convex or nonconvex problems, smooth or nonsmooth problems, and small-scale or large-scale problems. Contemporary optimization problems in, e.g., machine learning, signal reconstruction, control, and statistical estimation are often large-scale. The research in this group is focused on understanding and developing efficient algorithms for solving such problems. We focus on convex and nonsmooth problems with a primary focus is on so-called operator splitting methods and their stochastic variants. In particular, we develop frameworks for understanding a wide range of operator splitting methods that allow for a unified analysis and paves the way for design of new and improved algorithms. We also develop tools for automated algorithm analysis in which a so-called performance estimation optimization problem is formulated that exactly captures the worst possible performance of an optimization algorithm for some user-specified class of optimization problems. A solution to this, typically small-scale, performance estimation problem can give convergence guarantees for the analyzed algorithm.

SCALABLE OPTIMIZATION FOR CONTROL SYSTEMS

Researcher: Rantzer, Anders

Funding: ELLIIT

Modern control systems put new demands on control theory. Many of the modelling, analysis and design methods available do not scale well with increasing complexity. Applications and/or industrial practice often relies on distributed control structures, and there is a strong need for more systematic approaches to design and analysis of such structures and the corresponding information interfaces, especially with the development of "internet of things" and the so-called "smart society".

An important challenge for control and optimization is industrial robots where the task is to plan and carry out an operation as fast as possible given a number of constraints in terms of accelerations, loads on the mechanical structure, energy consumption, etc. The constraints in combination with dynamical models of very high complexity imply a strong need for efficient optimization methods. There are several challenges. One is that the dynamics is nonlinear making the optimization problem highly non-convex.

Another is that re-planning of operations in real time due to obstacles makes the need for efficient optimization methods much more relevant than before. Current industrial standard does not allow for re-planning. Optimization for industrial robots has not been considered in previous ELLIIT projects. The vision is to within 5 years have online optimization routines performing planning and re-planning of optimal robot trajectories in real time. Another important challenge for control and optimization is robustness analysis of large-scale interconnected systems

such as power grids. The introduction of renewables in the power grid requires high-fidelity models, which also imply a strong need for more efficient optimization methods. In this project we will investigate and develop new optimization methods and software for modelling, analysis and design of large-scale control systems that scale well with problem size. Within ELLIIT we have previously developed scalable robustness analysis methods assuming that suitable models where available. For systems like power grids, this is not the case. A major challenge is to in a distributed manner obtain linearized models for power grids, and to in a distributed manner build so-called LPV models which capture the uncertainties of the power grid. The vision for 5 years is to have efficient tools for modelling power-grids based on the Modelica modelling language which admits efficient analysis of robustness of the grid. This work will be carried out in collaboration with ABB Corporate Research in Switzerland.

OPTIMAL ESTIMATION AND CONTROL AT SCALE

Researcher: Pates, Richard; Adlercreutz, Julia; Hansson, Anders, Linköping University

Funding: ELLIIT

Many classical optimal methods for estimation and control have provable robustness and performance guarantees that can enhance the sustainability and resilience of engineering systems. However, their implementation typically requires all-to-all communication of sensor measurements, making them an infeasible choice for many practical applications. The aim of the project is to systematically investigate optimal estimation and control approaches through the lens of sparse linear algebra. In particular, the project aims to exploit techniques from sparse linear algebra to reduce the communication burden of classical optimal estimation and control methods. Reducing the need for communication will allow these methods to be applied in important sensor rich application areas, such as autonomous vehicles, transportation networks, and power grids. This has the potential to greatly improve energy efficiency and resilience in these applications, where suboptimal design approaches, that typically provide no formal guarantees, must currently be used for reasons of system scale.

VISUAL ANALYTICS OF LARGE AND COMPLEX MULTILAYER TECHNOLOGICAL NETWORKS

Researchers: Kerren, Andreas, Linköping University; Pates, Richard

Funding: ELLIIT

Multilayer networks are a relatively new way to model complex real-world systems that demand novel and efficient solutions for their analysis. Especially when regarding large and heterogeneous data typically used in power systems control, the use of multilayer networks for data representation, modeling, and analysis is promising. To explore such multilayer technological networks and to incorporate the human perspective into the analysis process for increasing the trust into the results, interactive visualization approaches are key. This project will be performed in an interdisciplinary team; we will study and develop novel visual analytics approaches for the exploration and analysis of multilayer technological networks, which is not only highly relevant for the field of visual analytics, but also for the energy efficiency of power systems.

BREGMAN OPTIMIZATION ALGORITHMS

Researcher: Giselsson, Pontus; Nilsson, Max

Funding: WASP

First-order optimization methods are methods of choice for large scale optimization problems. In general, such methods are poor at adapting to the geometry of the problem and can perform poorly on ill-conditioned problems. This projects investigates the class of so-called Bregman first-order optimization methods that are designed to better capture the problem geometry than traditional first-order methods do. We investigate theoretical properties as well as their application in applications domains such as machine learning training.

MODEL PREDICTIVE CONTROL STABILITY ANALYSIS

Researcher: Giselsson, Pontus; Åkerman, Anton

Funding: WASP

Model predictive control is a control scheme in which an optimization problem is solved to find the next control action to apply. Explicit solutions rarely exist, and the optimization problem is typically solved using an optimization algorithm. The control application sets hard limits on how much time can be spent on solving the optimization problem each iteration. Most theory for model predictive control assumes that the optimization problems are solved to optimality, which is not feasible in practice. This project aims at establishing new theory for model predictive control stability analysis with the restriction that the optimization algorithm can only run a finite and pre-defined number of algorithm iterations each time a new problem is solved.

AUTOMATIC LYAPUNOV ANALYSIS OF OPTIMIZATION ALGORITHMS

Researchers: Giselsson, Pontus; Banert, Sebastian; Upadhyaya, Manu

Funding: VR and WASP

This project aims at automating the process of analysis and design of optimization algorithms. The basis of the project is to formulate the problem of analyzing convergence of an optimization algorithm as another optimization problem. This problem finds the worst case function, within the class of considered functions, given a performance metric. Based on this, we develop methodologies for finding Lyapunov functions for proving convergence, devise new algorithms, and find extended convergent parameter regions for existing methods

AUTONOMOUS REAL-TIME SYSTEMS

A significant part of the research in this field revolves around cyber-physical systems, clouds, and cloud control. Historically, control systems have been deployed as monolithic software implementations on carefully tuned hardware, adjacent to the plants they control. This has resulted in systems that are undesirably non-modular, not easily extensible and that have limited ability to self-adapt. In contrast, feedback-based cyber-physical systems and cloud-native applications offer the prospect of greater accessibility and flexibility, as well as higher reliability and lower latencies. Furthermore, when applications are implemented in a disaggregated manner, their execution can be distributed across the system's many nodes, migrated, and scaled to meet individual objectives as well as that of the system as a whole.

Ongoing projects:

- Ad-hoc Compute Offloading for Autonomous Connected Vessels
- Advanced Offloading for Real-Time Applications - AORTA
- Optimizing Radio Access Networks for Efficient Massive MIMO
- Robust and Secure Control over the Cloud
- Towards Adaptively Morphing Embedded Systems - ADMORPH

AD-HOC COMPUTE OFFLOADING FOR AUTONOMOUS CONNECTED VESSELS

Researchers: Eker, Johan; Sundström, Emil

Funding: WASP WARA

In this WASP funded project we will develop methods and tools to support dynamic offloading of demanding compute and AI functionality from limited connected devices to the cloud. Offloading can be used to save power and battery life, and also improve performance. Dynamics offloading requires several components. First, an application model that supports components to execute both locally and, in the cloud, and migrate in between, is needed. Second, methods to handle the orchestration of components during run-time and dynamically allocate resources, including network (5G) and compute resources. The project targets the WARA Public Safety arena and is aimed at extending the services available for the drones and boats used in the demonstrator.

Figure: The project will target the WARA-PS rescue scenario, which involves a set of cooperating Connected drones and autonomous boats..

ADVANCED OFFLOADING FOR REAL-TIME APPLICATIONS - AORTA

Researchers: Årzén, Karl-Erik; Eker, Johan; Al-Bayati, Ahmed

Funding: Vinnova

The goal of AORTA is to develop a framework that allows offloading of real-time services and functionality to the edge and cloud, as well as integration of them with services in the edge/cloud.

The ambition is to support, for example advanced robotics or manufacturing applications in utilizing non-local services in a predictable fashion. We will build upon recent advances in predictable communication and compute technologies, such as TSN, Kubernetes and 5G. A new real-time computing platform consisting of a portable real-time virtual machine that supports dynamic code migration for offloading.

OPTIMIZING RADIO ACCESS NETWORKS FOR EFFICIENT MASSIVE MIMO

Researchers: Pjanic, Dino; Tufvesson, Fredrik; Bernhardsson, Bo

Funding: SSF

Massive MIMO has today been incorporated as one of the main technologies in the standard to meet the requirements for 5G. While the core technology is in place, there are still many open topics with respect to the implementation and optimization of the cellular network using this technology. In this project, we aim for a machine learning approach for efficient operation of cellular networks based on massive MIMO. The many antennas in massive MIMO base stations give access to details in the radio channel and opens up for better prediction of both small scale behaviour such as user correlation as well as large scale behaviour such as mobility patterns. This in turn can lead to new opportunities with respect to scheduling approaches and handover strategies in order to provide low latency reliable user connection in mixed and dynamic environments.

The project is divided into four work packages

1. Long and short term channel prediction in massive MIMO
2. Mobility and traffic pattern estimation, handover prediction
3. Physical and virtual UE positioning based on network data, and
4. 5G user scheduling based on machine learning.

We will use a mix of experiments from the massive MIMO testbed at Lund University together with state of the art network simulators and real world traffic patterns to achieve our end goal: A machine learning enabled scheduling framework for mixed traffic in realistic 5G networks.

ROBUST AND SECURE CONTROL OVER THE CLOUD

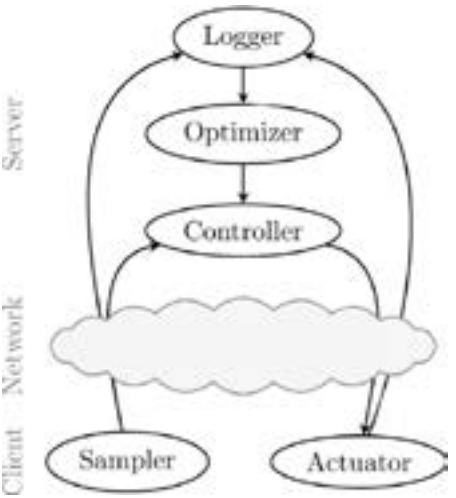
Researchers: Nyberg Carlsson, Max; Årzén, Karl-Erik and Peng, Zebo; Eles, Petru; Pan, Yungang, Linköping University

Funding: ELLIIT

The ELLIIT-funded research project Robust and Secure Control over the Cloud runs between 2021 and 2025 and is a collaboration between the Department of Automatic Control and the Embedded Systems Laboratory at Linköping University, with one PhD student at each site. The project will develop theory and design methodology to explore the interplay between local and cloud-based control as well as the trade-offs between robustness, security, and adaptivity. The Lund team focuses on the control and autonomy aspects, while the Linköping team focuses on security and optimization. The results will be verified in real feedback control experiments over the Cloud.

The Cloud, with its virtually infinite storage and computing capacity, provides ample opportunities for applying advanced control and estimation algorithms in completely new settings. While local feedback is needed to ensure the stability of individual control applications regardless of the current status of the network, the cloud is ideal for running high-level control and optimization algorithms in large-scale networked systems. Compute-intensive algorithms such as model-predictive control (MPC), particle filtering, and reinforcement learning can exploit the massive amounts of data generated by local devices to continuously adapt to the circumstances and optimize the overall system behavior. Fast-growing market demands, the need to reduce production cost, flexible product lines, and scalability issues are all driving forces towards shifting the control applications from being implemented on dedicated hardware to pieces of software running in the Cloud.

During 2022, we investigated timing-robust control over the Cloud using online parametric optimization. The goal is to adapt a linear networked feedback to unpredictable timing complications, such as long delays, aborted computations, and dropped packets. The core concept of the approach is to log successful sampling and actuation events and then, at regular intervals, use non-convex parametric optimization to improve the expected performance of the controller under the assumption that the future timing behavior will be similar to the current one. The expected future cost is computed using our Julia toolbox JitterTime.jl. To reduce the time complexity of the optimization algorithm, automatic differentiation in Julia is applied for efficient gradient descent. The approach has been evaluated on a physical ball and beam plant, where both the controller and optimization algorithm can be located in the Cloud.



TOWARDS ADAPTIVELY MORPHING EMBEDDED SYSTEMS - ADMORPH

Researchers: Maggio, Martina; Vreman, Nils; Heimerson, Albin

Funding: EU Horizon2020

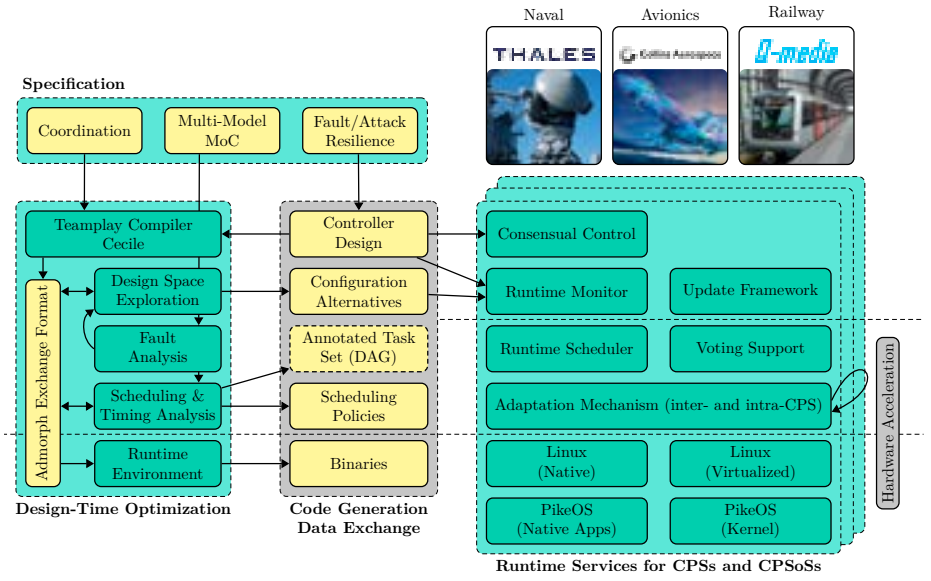
Due to the increasing performance demands of mission- and safety-critical Cyber Physical Systems (of Systems) – CPS(oS) – these systems exhibit a rapidly growing complexity, manifested by an increasing number of (distributed) computational cores and application components connected via complex networks.

However, with the growing complexity and interconnectivity of these systems, the chances of hardware failures as well as disruptions due to cyber-attacks will also quickly increase. System adaptivity, foremost in terms of dynamically remapping of application components to processing cores, represents a promising technique to fuse fault- and intrusion tolerance with the increasing performance requirements of these mission- and safety-critical CPS(oS). In the ADMORPH project, we evaluate this hypothesis using a novel, holistic approach to the specification, design, analysis and runtime deployment of adaptive, i.e., dynamically morphing, mission- and safety-critical CPS(oS) that are robust against both component failures and cyber-attacks. To this end, we will address four aspects that are instrumental for the realisation of these adaptively morphing systems:

- the formal specification of adaptive systems
- adaptivity methods like strategies for maintaining safe and secure control of CPS(oS)
- analysis techniques for adaptive systems to, e.g., perform timing verification of adaptive systems to avoid timing violations after system reconfigurations
- run-time systems for adaptive systems that realise the actual run-time system reconfigurations to achieve fault and intrusion tolerance

The developed methodologies, methods and tools will be evaluated using three industrial use cases taken from the radar surveillance systems, autonomous operations for aircrafts, and transport management systems domains.

Conclusion: In the ADMORPH project, Lund University has shown that a core limitation of control design is the disconnection between the control algorithm and its implementation. However, it is possible to quantify the effect of timing anomalies such as deadline misses on the safety of the control system. By determining safe operational limits for the control system, we enabled the design of adaptation strategies that aim at resolving the computational problems before they cause damages.



INNOVATIVE CONTROL APPLICATIONS

This is an area of application-driven research motivated by the desire to create a more sustainable society. It addresses several of the UN's 17 Sustainable Development Goals. It also has an impact on LTH's five core research areas, meaning that this field of research is important in digitalization, industry, the built environment, our climate, and life itself.

Numerous applications are being addressed, for example, within robotics, health care, the process industry, and smart manufacturing. A substantial part of the research takes place in the robotics lab. Apart from research on automatic control, this focus area also concentrates on teaching and learning methods, standards for smart industries, and innovation indexes.

Much of the research is performed in collaboration with, and is co-funded by, industrial partners.

Ongoing projects:

- RobotLab
- Autonomous Flight (UAS@Lund)
- Autonomous Force-Aware Swift Motion Control
- Hand-arm coordination control for robotic interaction tasks
- Intelligent trajectory predictions at sea using neural ordinary differential equations
- Increasing the Speed of Analysis of Images Obtained from Unmanned Aerial Vehicule
- Hemodynamic Stabilization
- Data-driven Modeling for Sustainable Mining
- Historical Female Influencers in Automatic Control
- Learning Pharmacometric Model Structures from Data
- Realtime Individualization of Brain Computer Interfaces

ROBOTLAB LTH INFRASTRUCTURE

RobotLab LTH is a close collaboration between Deptartments of Automatic Control and Copmuter Science. Our main research is on autonomous robotic systems, with special focus on motion and compliance control, control and software system architectures, different sensor fusion problems, robot vision, and robot learning. RobotLab LTH has a long history of industrial collaboration. The lab had also spin-offs, e.g., Cognibotics AB and RiACT A/S. RobotLab LTH organizes a yearly outreach event for schools (a robotics week) attracting several hundred students each year in the context of the annual euRobotics Week. In addition, we also participate in other outreach activities like Her Tech Future, Kulturnatten, and similar events. RobotLab LTH is an Open Door lab that offers companies access to advanced robotics hardware and know-how. RobotLab LTH has hosted several Master Thesis projects in cooperation with industry, e.g., ABB, Axis, B&R, Modelon, Cognibotics, Combine, Bitcraze, TWI Ltd., Tetra Pak, and many more.

Equipment in the RobotLab

In RobotLab LTH there are ABB IRB120, IRB140, IRB2400, and YuMi with the IRC5 control system. Hardware interfaces have been developed to create an open system suitable for motion-control experiments and sensor feedback. A parallel-kinematic manipulator with a large working volume is available. A specialized robot for applications within construction robotics called Bettan is also available in the lab. We also have a KUKA IIWA dual-arm robot, and a UR5e and a Franka Emika Panda robot. Several mobile robot systems are also available: a Spot four-legged robot from Boston Dynamics, a MIR 200 wheeled mobile platform with a UR5e on top, and a mobile platform based on the Fraunhofer IPA Care-o-Bot/Rob-at-Work.

AUTONOMOUS FLIGHT (UAS@LUND)

Participants: Bergström, Johan; Tyllström, Rikard; Johansson, Rolf; Laban, Lara; Olofsson, Björn; Karayiannidis, Yiannis, in collaboration with Lund University School of Aviation.

This research project addresses and develops the technologies of unmanned flying systems (UAS or drones) in order to make such systems more suitable for addressing various social challenges. A current collaboration project (UAV@LU, currently changing name to UAS@LU) addresses the potential of UAS for addressing societal challenges including, but not limited to, more efficient and sustainable forestry and farming, urban planning and landscape modelling, monitoring of critical infrastructure system, smarter transport, as well as more efficient and safe emergency service operations. A problem shared across all sectors mentioned above is making the UAS autonomous; the transition from actively piloting a UAV with continuous (human) control inputs from a remote ground station while having the UAV within visual line of sight to an autonomous UAS solving complex problems without continuous human control inputs but as an autonomous agent beyond the visual line of sight in an airspace populated by unmanned as well as manned aircraft. Consequently, the here proposed research project aims at developing and demonstrating autonomous flight missions in an airspace with mixed autonomous and manned aircraft under supervision and management of air traffic control. While the actors in the UAS@LU network represent a vast number of possible applications for autonomous UAS systems; this project will focus on two applications which are being developed with the purpose of enhancing societal safety: the cases of autonomous radiation detection and Sear-And-Rescue (SAR). The project serves the wider purposes of the collaboration UAS@LU and is conducted by Lund University School of Aviation and the Lund University Deptartment of Automatic Control in close collaboration with research conducted at the departments for Nuclear Physics and Medical Radiation Physics. External actors include those involved in Testbed Ljungbyhed as well as actors collaborating with LU researchers in UAS applications for societal safety.

AUTONOMOUS FORCE-AWARE SWIFT MOTION CONTROL

Researcher: Jia, Zheng; Olofsson, Björn; Karayiannidis, Yiannis in collaboration with colleagues at Linköping University

Funding: ELLIIT

The research program for this project has a number of steps for moving autonomous force-aware swift motion control forward. Our recently derived novel methods for at-the-limit maneuvering will be extended to new scenarios, where previously non-dynamic kinematic models (with non-holonomic motion constraints) have been used under, sometimes highly restrictive, assumptions on limited slip and upper-bounded velocities. For example, maneuvering in highway driving at higher speeds (typically 70 km/h and higher) implies that consideration of the forces involved, i.e., the dynamic behavior, is of importance, e.g., if heavy-duty vehicles with their inherent roll sensitivity or mobile platforms with heavy manipulators onboard are considered. The new perspective has high potential to lead to new significant results with regard to planning and control strategies for a wide range of vehicle-maneuvering and robotic manipulation scenarios, and will also treat scenarios with multiple vehicles and moving robots, in traffic or on work sites. The core of the project is scientific questions in swift motion control that is safe, resilient, and efficient.

HAND-ARM COORDINATION CONTROL FOR ROBOTIC INTERACTION TASKS

Researchers: Guberina, Marko; Karayiannidis, Yiannis; Olofsson, Björn

Funding: ELLIIT

The focus of the research project is the problem of robotic hand-arm coordination for the purpose of manipulation. Hand-arm coordination refers to simultaneous movement of robotic manipulators (arms) and grippers (hands) during object manipulation. This is contrasted by rigid grasping used in most current robotic manipulation.

The objective is to enhance robots' overall performance by overcoming the limitations of rigid grasping by allowing and controlling motion of the grasped object. Controlled regrasping enables faster task execution and smoother operation by enhancing the manipulability of the whole arm-hand-object system throughout robots' tasks. Apart from resulting in higher efficiency of the robotic system, hand-arm coordination also results in more natural and intuitive looking robotic motion.

In broader terms, the aim of the project is to develop sensor-based controllers that can endow robots with combined grasping and manipulation capabilities. The need for this comes from the desire of having robots work with and in human designed environments, and releasing the requirement for creating environments tailored to robots.

INTELLIGENT TRAJECTORY PREDICTIONS AT SEA USING NEURAL ORDINARY DIFFERENTIAL EQUATIONS

Researchers: Stoltenberg, Peter; Karayiannidis, Yiannis; Olofsson, Björn in collaboration with Saab Kockums

Funding: WASP

This is an Industrial PhD student project in collaboration with Saab Kockums within the Wallenberg AI, Autonomous Systems and Software Program (WASP).

This project develops methods for trajectory predictions of surrounding vessels at sea, by modeling of the interacting vessels combined with neural ordinary differential equations (ODEs), relying on input from a perception system, with the purpose of presentation to a human operator or utilization in an automated planning and control system. Operators of sea vessels make decisions about actions based on the current situational understanding, and how they predict various types of vessels will behave in the specific environment that they are operating in. Having models for such functionality, is a requirement for high-performance (semi-)autonomous sea vessels, and is significantly relevant for both manned vessels and autonomous surface vessels in dense and narrow environments like archipelagos and ports. Compared to the established approach in use in many systems, where trajectories of surrounding vessels are extrapolated holding a straight line and a constant velocity, the approach taken in this project contributes to a more realistic situational understanding and prediction by relying on an interaction-aware and physics-aware model that ensures physically reasonable and situation-specific trajectory predictions as output from the model.

The research questions that are the focus of this project are:

- How can modeling of interactions combined with neural ODEs and other known information be used for model-based trajectory predictions to achieve robust and safe naval autonomy?
- How should uncertainty for trajectory predictions be quantified and actively managed by interactions with the perception system in multi-agent settings for sea vessels?
- How should the system architecture for implementation of model-based trajectory prediction systems be designed to enable interactions with surrounding system components for full autonomy in naval applications?

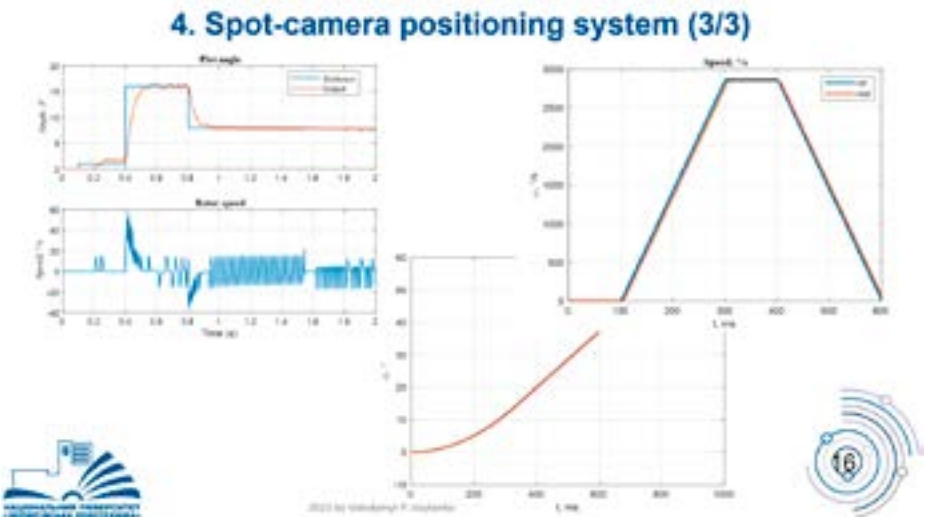
INCREASING THE SPEED OF ANALYSIS OF IMAGES OBTAINED FROM UNMANNED AERIAL VEHICLE

Researcher: Voitenko, Volodymyr

Funding: KAW

The role of drones today, as well as their future, cannot be overestimated. UAVs are a source of valuable information about the world around us. However, the volume of this information received from the onboard video camera during a long mission is so great that it leads to pilot fatigue. To prevent missing the desired object and the occurrence of occupational diseases, a solution based on an automatic control system is proposed.

In this interdisciplinary project, principles are being developed for constructing a software and hardware complex containing an onboard object detector and a system for precise positioning along two coordinates of an additional camera with a narrow field of view. An electromechanical system, based on a inference made by artificial intelligence, orients the spot camera, providing the operator with an enlarged image, and the final solution (classification) of objects is implemented by a person.



HEMODYNAMIC STABILIZATION

Researchers: Soltesz, Kristian; Pigot, Harry; Wahlquist, Ylva; Paskevicius, Audrius (Heart and Lung transplantation), in collaboration with Igelösa Life Science

Funding: VR, Vinnova

Testing of a device for functional heart evaluation, with an actively controlled flow resistance (right) connected to a porcine heart. Blood is supplied to the organ via a compliant column (left). The device is designed to mimic the normal physiology of a prospective transplantation patient. The clinical application of this technology would help increase the number of available donor hearts that can safely be used in transplantation

Intensive care patients often rely on a combination of drug, fluid, and other therapies to achieve and maintain stable hemodynamics. This projects investigates how pharmacology, mathematical modeling, signal processing and closed-loop control can be combined to control hemodynamic entities such as blood pressure, heart rate, and vascular resistance, as well as related entities such as diuresis. The research relies on close inter-disciplinary collaboration between medical and control systems researchers. It is conducted in a systems engineering framework and comprises the development of both methods and dedicated equipment for clinical verification.

The aim of the project is to develop methods for hemodynamic stabilization of intensive care patients. It comprises closed-loop control of

readily measurable signals, including heart rate, arterial and venous blood pressure. Furthermore, the project aims at optimizing hemodynamic parameters, which are not directly measurable, such as cardiac output and responsiveness to volume expansion.

The aim of the project is to develop a generic platform for closed-loop intravenous drug delivery. Apart from being used in research, such a platform can be adapted to a multitude och medical treatment scenaraios, foremost in intensive care, where it has the potential to increase the availability of specialized physicians.

The aim of the project is to provide physicians with an 'auto pilot' for hemodynamic stabilizatioin and optimization. The initially considered patient group are heart-beating braindead patients under intensive care (potential organ donors). Due to the complete loss of vasomotor center function, hormonal and fluid therapy is required to establish hemodynamic stability within this group.

We combine automatic control methods with medical insight, to develop closed-loop controlled therapies. Developed methods are implemented on our in-house developed control system comprising sensors for invasive blood pressure measurement, and urination rate, as well as syringe and volumetric infusion, pumps for closed-loop controlled intravenous drug and fluid administration.

The methods are pre-clinically evaluated in collaboration with the project partner Igelösa Life Science AB.

DATA-DRIVEN MODELING FOR SUSTAINABLE MINING

Researcher: Norlund, Frida; Soltesz, Kristian; Eker, Johan; Bauer, Margret

Funding: WASP

Flotation is the dominating process in the global copper, lead, and zinc mining industries to separate valuable minerals from waste material. In the upstream process steps, the ore is ground to liberate all mineral grains, and mixed with water to form a slurry. In flotation, chemical reagents are added to improve the hydrophobic properties of selected minerals. When air is added, these minerals follow the air bubbles to the surface and can be extracted in the resulting froth, forming a concentrate. This process is implemented in flotation tanks interconnected in a complex circuit that often includes re-grinding and recirculation. Floatation is a pivotal process step, as it defines the recovery (yield), which has a proportional impact on both environmental aspects and the financial result of the company.

Today, the flotation process is typically controlled semi-manually, where simple control loops stabilize tank levels and flow rates, while operators adjust parameters like airflow, reagent- and lime- addition based on the available measurements and experience. Model predictive control solutions have been attempted, with some success. However, performance is severely limited by poor model accuracy and the inability to adapt to changes in ore properties as new areas of the mine are excavated. To increase efficiency and autonomy of mineral processing, these challenges must be addressed.

Therefore, this PhD project addresses modeling of the flotation process for control purposes. Data-driven modeling through machine learning (ML) techniques holds great potential, but several aspects must be addressed before it can be applied in an industrial setting. In our setting, observation of a process is limited by physical restrictions and the available measurement technology. Furthermore, the effect of the measured properties on the system state are often both

Above: Photo of the flotation series in the Aitik concentrator, located near Gällivare, Sweden.
Photo credit: Jonas Westling.

complicated and only known conceptually, making the interpretation of the measurements challenging. To use the limited data that is available efficiently, we will combine machine learning with physics-based modeling, avoiding wasting scarce data on learning known laws of physics.

In this project, we will therefore push the state-of-the-art within mining process control by complementing machine learning with physics-based models based on e.g., conservation laws

We firmly believe that the future of floatation control, and indeed many associated process steps, lies in incorporating informal operator know-how into dynamical models, to enable model-based control solutions, where traditional data-driven paradigms suffer from lack of informative data. This physics-informed machine learning approach to increased autonomy is becoming increasingly feasible thanks to advances within scientific machine learning methodology. Within mining and the process industries, embracing it will provide the opportunity to increase efficiency of resource utilization, thereby enabling the transition to a sustainable technological future.

HISTORICAL FEMALE INFLUENCERS IN AUTOMATIC CONTROL

Researchers: Johnsson, Charlotta; Westin, Eva; Hägglund, Tore; Soltesz, Kristian; Bauer, Margret; together with X-Lab and Campus Helsingborg

Funding: IFAC Activity Fund

It is interesting to look at the presence of role models in the automatic control community. The senior professionals in this field influence the younger, and thereby shape the younger generation. There are many occasions where younger, potential future control professionals, could be influenced by elder professionals. One occasion is in the class room e.g. when examples of pioneers in the field are highlighted. Another example is in the everyday working environment e.g. laboratories or offices, where experiences and history from the passed are shared. Yet another example are the award winners in the field, who just by getting the price raises their influence in the field.

Statistics from e.g. Department of Automatic Control, Lund University, Sweden, show that only 12 out of the 142 PhD theses, throughout its 60 years of history, are written by women. Statistics also show that only 9% of the PhD-students, and 9% of the professors are of female gender. These numbers are very low. Most probably the statistics from automatic control departments in other corners of the world, are very similar.

So could it be that female role models are missing? It is noted that early pioneers highlighted in basic control courses often (or always) are men e.g. Bode, Nyquist, Kalman, etc. Also, award winners are to a very large degree men, e.g. the Richard E Bellman Award was given to a man 40 years in a row. This is explained by the fact that there are few women in the field, but how could they enter if there are hardly no role models to identify with?

The intention of this project is to make visible some early female historical influencers. We believe that the best way to do this is to identify a set of elder (retired or emeritus) female professionals, and by interviewing them get to know if they themselves had any female role models. We also believe that the identified (retired or emeritus) female control professionals, act as role models, female influencers in themselves. The interviews with the female control professionals serve as material for a portrait-series of historical female influencers. The portrait-series can be used in various outreach material such as e.g. lecture notes, and other inspirational material for young and potential future control professionals. By this project we hope to inspire more females to enter the community of Automatic Control.

Bozenna Pasic-Duncan

(b.1947)

"If you choose only one course at the university, choose mathematical statistics because we deal now with data, randomness, and uncertainty.

Nina F. Thornhill

(b.1953)

"You can find anything you want in data, but whether it is meaningful requires one to understand the processes behind the analysed systems.

Eveline Gottzein

(b.1931)

"I was fascinated by the opportunities and determined to use them to the greatest possible extent.

Sirkka-Liisa Jämsä-Jounela

(b.1952)

"If you are interested in and love your work, you will be successful.

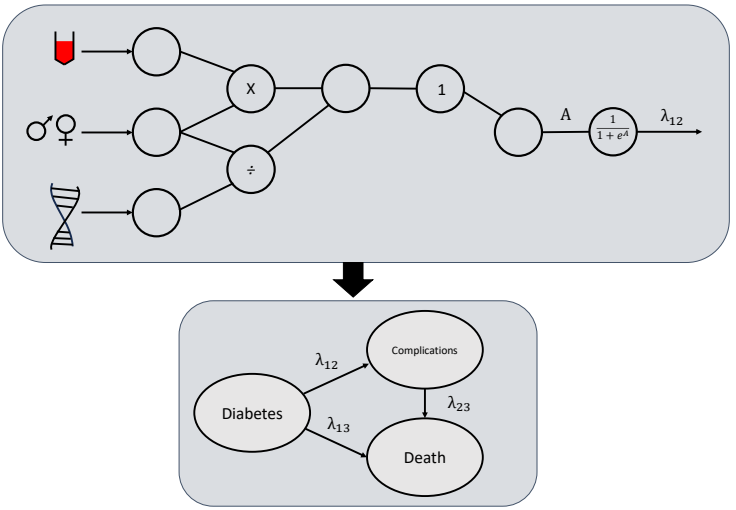
LEARNING PHARMACOMETRIC MODEL STRUCTURES FROM DATA

Researchers: Bernhardsson, Bo; Sundell, Jesper; Wahlquist, Ylva; Soltesz, Kristian

Funding: WASP

Pharmacometric models are mathematical models aiming to describe the relationship between pharmaceutical therapy and patient response. A central aspect of pharmacometric models is prediction of individual responses to therapy based on covariates (i.e. patient characteristics). Such individual predictions constitute the foundation of precision medicine with the ultimate goal of optimal therapy in each patient. The covariates have historically been limited to patient demographics such as weight, height and sex and the covariate modelling has focused on which covariates that are relevant for prediction of response. The appropriate mathematical structure of the covariate model has received less attention.

Expanding knowledge on an individual patient level due to collection of additional data such as genetic and life-style data offers opportunity to improve individual predictions by pharmacometric models. This project aims to develop methodology capable of handling such increasingly complex data. The project further has a focus on developing methods for identification of mathematical structures of covariate-response relationships based on machine learning.



Caption: Artificial neural networks may be used to describe and predict individual differences in risk of developing disease-related complications based on patient specific factors such as genetics and gender

REALTIME INDIVIDUALIZATION OF BRAIN COMPUTER INTERFACES

Researchers: Bernhardsson, Bo; Heskebeck, Frida; Tufvesson, Pex; Gemborn Nilsson, Martin; in collaboration with Maria Sandsten, Rachele Anderson at Mathematical Statistics, LTH and Mikael Johansson at department of Psychology.

Funding: WASP, ELLIIT, Ericsson

Controlling the physical world with our mind only opens up for a vast number of exciting opportunities. This can be made possible through so called Brain Computer Interfaces (BCIs). In this project, we primarily focus on BCIs based on ElectroEncephaloGram (EEG) measurements, collected through the use of an EEG-cap. Although the technology behind BCIs have improved steadily over recent years, there is still much to be done. We investigate what the possibilities and limitations of BCIs are in terms of efficiency, reliability and individualizability.

The project is a collaboration between the Department of Automatic Control, the Department of Mathematical Statistics and the Department of Psychology at Lund University. Bringing together cross-disciplinary expertise, we have identified several critical obstacles that prevent BCIs from becoming a truly life-changing technology, and methods to overcome them. We see several important areas of use such as communication and control for severely motor-impaired users, smart hearing aids, gaming-devices and forensics tools, as well as different health-related applications, such as rehabilitation, including restoration of motor control after stroke.

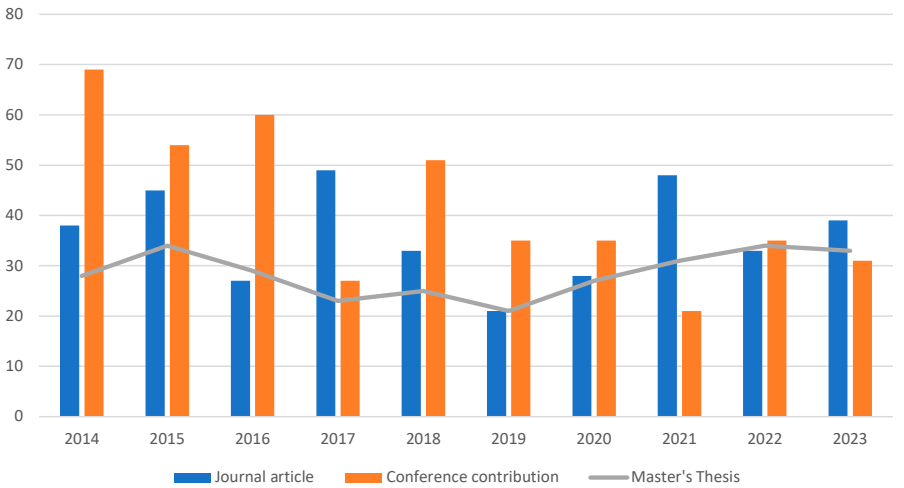
Demo by Pex Tufvesson and Martin Gemborn Nilsson

Publications and seminars

This chapter contains a list of publications and seminars during 2023

PUBLICATIONS 2023

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.



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BOOK CHAPTER

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Sjögren, Julia; Fransson, Per-Anders; Patel, Mitesh; Lundén Blom, Christoffer; Johansson, Rolf; Magnusson, Måns and Tjernström, Fredrik; *Reduced Vestibulo-Ocular Reflex During Fast Head Rotation in Complete Darkness.* In Perceptual and Motor Skills.

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Wilroth, Johanna; Bernhardsson, Bo; Heskebeck, Frida; Skoglund, Martin A; Bergeling, Carolina and Alickovic, Emina; *Improving EEG-based decoding of the locus of auditory attention through domain adaptation*. In Journal of Neural Engineering.

Vladu, Emil and Rantzer, Anders; *On Decentralized H-Infinity Optimal Positive Systems*. In IEEE Control Systems Letters 7. p.391-394.

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Zhou, Jian; Olofsson, Björn and Frisk, Erik; *Interaction-Aware Motion Planning for Autonomous Vehicles with Multi-Modal Obstacle Uncertainty Predictions*. In IEEE Transactions on Intelligent Vehicles.

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Agner, Felix; Hansson, Jonas; Kergus, Pauline; Rantzer, Anders; Tarbouriech, Sophie and Zaccarian, Luca; *Decentralized PI-control and Anti-windup in Resource Sharing Networks*.

Alpturk, Cem and Renganathan, Venkatraman; *Path Planning Using Wasserstein Distributionally Robust Deep Q-learning*. European Control Conference, ECC 2023.

Balador, Ali; Eker, Johan; Ul Islam, Raihan; Mini, Raquel; Nilsson, Klas; Ashjaei, Mohammad; Mubeen, Saad; Hansson, Hans and Årzén, Karl-Erik; *AORTA: Advanced Offloading for Real-time Applications*. Real-Time Cloud (RT-CLOUD), 2023.

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Cianfanelli, Leonardo ; Ambrogio, Alexia and Como, Giacomo; *Information Design in Bayesian Routing Games,* 62nd IEEE Conference on Decision and Control, CDC 2023 p.3945-3949

Dahlin, Albin and Karayiannidis, Yiannis; *Obstacle Avoidance in Dynamic Environments via Tunnel-following MPC with Adaptive Guiding Vector Fields*. 2023 62nd IEEE Conference on Decision and Control (CDC) p.5778-5783.

Ekenberg, Kajsa; Renganathan, Venkatraman and Olofsson, Björn; *Distributionally Robust RRT with Risk Allocation*. 2023 IEEE International Conference on Robotics and Automation p.12693-12699.

Hansson, Jonas and Tegling, Emma; *A closed-loop design for scalable high-order consensus*. 62nd IEEE Conference on Decision and Control.

Grönqvist, Johan; and Rantzer, Anders; *Verification of Low-Dimensional Neural Network Control.* 62nd IEEE Conference on Decision and Control, CDC 2023 p.4566-4571.

Heimerson, Albin and Ruuskanen, Johan; *Extending Microservice Model Validity using Universal Differential Equations*. p.2401-2406.

Heskebeck, Frida; *Discussion Seminars – an Award-winning Pedagogical Method.*

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Jena, Ayesha and Topp, Elin Anna; *Chaos to Control : Human Assisted Scene Inspection*. 18th Annual ACM/IEEE International Conference on Human-Robot Interaction, HRI 2023 In ACM/IEEE International Conference on Human-Robot Interaction p.491-494.

Jouini, Taouba Kaouther; Sun, Zhiyong; Renganathan, Venkatraman and Hagenmeyer, Veit; *Input and state constrained inverse optimal control with application to power networks*. *22nd IFAC World Congress p.5451-5456.*

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Lefeber, Erjen; Greiff, Marcus and Robertsson, Anders; *A Robust Observer with Gyroscopic Bias Correction for Rotational Dynamics.* 22nd IFAC World Congress In IFAC-PapersOnLine 56(2). p.1641-1648.

Mogensen, Søren Wengel; *Instrumental Processes Using Integrated Covariances*. 2nd Conference on Causal Learning and Reasoning, CLeaR 2023 In Proceedings of Machine Learning Research 213. p.620-641.

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Ráth, Andre LU; Pjanic, Dino; Bernhardsson, Bo and Tufvesson, Fredrik; *ML-Enabled Outdoor User Positioning in 5G NR Systems via Uplink SRS Channel Estimates*. 2023 IEEE International Conference on Communications, ICC 2023 In IEEE International Conference on Communications 2023-May. p.2215-2220.

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Savasci, Mehmet; Ali-Eldin, Ahmed; Eker, Johan; Robertsson, Anders and Shenoy, Prashant; *DDPC : Automated Data-Driven Power-Performance Controller Design on-the-fly for Latency-sensitive Web Services*. 2023 World Wide Web Conference, WWW 2023 In ACM Web Conference 2023 - Proceedings of the World Wide Web Conference, WWW 2023 p.3067-3076.

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Solodchuk, Maksym and Voytenko, Volodymyr; *Onboard object detector hardware for an unmanned aerial vehicle*. The latest technologies in scientific activity and the educational process p.251-253.

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Tärneberg, William and Skarin, Per; *Constructive Dissonance in the Cloud: Adaptive Out-of-Phase Scheduling for Periodic Tasks*. International Conference on Cloud Networking.

Westny, Theodor; Oskarsson, Joel; Olofsson, Björn and Frisk, Erik; *Evaluation of Differentially Constrained Motion Models for Graph-Based Trajectory Prediction*. IEEE Intelligent Vehicles Symposium (IV 2023).

Wijnbergen, Paul; Jeeninga, Mark; de Haan, Redmer and Lefeber, Erjen; *Decentralized lateral and longitudinal control of vehicle platoons with constant headway spacing*. Proceedings of the 2023 62nd IEEE Conference on Decision and Control

Voytenko, Volodymyr; Denisov, Yuriy; Yershov, Roman and Solodchuk, Maksym; *A conceptual model for increasing the speed of decision-making based on images obtained from UAVs*. Mathematical Modeling and Simulation Systems In Lecture Notes in Networks and Systems 667.

PHD THESES

Heimerson, Albin; *Learning to Control the Cloud*. PhD Thesis, Department of Automatic Control, Lund University, Sweden, November 2023.

Vreman, Nils; *Analysis of Embedded Controllers Subject to Computational Overruns*. PhD Thesis, Department of Automatic Control, Lund University, Sweden, June 2023.

LICENCIATE THESES

Agner, Felix; *On Hydraulic Constraints in Control of District Heating Systems*. Licentiate Thesis, Department of Automatic Control, Lund Unversity, Sweden, March 2023.

Hansson, Jonas; *Transient Analysis and Control for Scalable Network Systems*. Licentiate Thesis, Department of Automatic Control, Lund Univeristy, Sweden, September 2023.

Heskebeck, Frida; *On Calibration Algorithms for Real-Time Brain-Computer Interfaces*.Licentiate Thesis, Department of Automatic Control, Lund Univeristy, Sweden, October 2023.

Lindberg, Johan; *On H2 and H-infinity Optimal Control of Mass-Spring Networks with Power System Applications*. Licentiate thesis, Department of Automatic Control, Lund Univeristy, Sweden, December 2023.

Salt Ducaju, Julian; *Human-Robot Collaboration for Kinesthetic Teaching*. Licentiate Thesis, Department of Automatic Control, Lund University, Swedden, January 2023.

TECHNICAL REPORT

Rasmusson, Monika; Soltesz, Kristian (Eds); *Activity Report 2022 Automatic Control Lund University*. Technical Report, Department of Automatic Control, Lund University, Lund, Sweden, April 2023.

MASTER THESES

Åkerman, Anton; *Optimizing First-Order Method Parameters via Differentiation of the Performance Estimation Problem*. Master's Thesis TFRT-6204. Supervisors: Giselsson, Pontus and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

Allander, Linnea and Nordtorp, Torben; *Qualitative Image Selection with Active Learning*. Master's Thesis TFRT-6198. Supervisors: Sjöbom, Joel and Person, Emma (external); Giselsson, Pontus and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Belfrage, Esaias and Borna, August; *Generative AI for Synthetic Data*. TFRT-6200. Supervisors: Holmberg, Torgny (external); Eker, Johan and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Byström, Richard and Sjödin, William; *Enhancing GNSS Precision for Mobile Devices with Sensor Fusion Techniques: A Case Study on eBike Tracking Using State Estimation*. Mater's Thesis TFRT-6212. Supervisors: Heyden, Martin and Noll, Stefan (external); Karayiannidis, Yiannis and Olofsson, Björn, Department of Automatic Control, Lund University.

Challa, Nikhil; *Estimation of Parabolic Microwave Antenna Movements Using Sensor Fusion*. Master's Thesis TFRT-6218. Supervisors: Broström, Henric and Isaksson, Frans Erik (external); Bernhardsson, Bo and Tegling, Emma, Department of Automatic Control, Lund University.

Djärf, Tim; *Practical Trials of Fiber Optical Gyroscope Based Inertial Navigation System*. Master's Thesis TFRT-6196. Supervisors: Krantz, Karl-Johan (external); Bernhardsson, Bo and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Elgcrona, Erica and Mete, Evrim; *Latency Prediction in 5G Networks by using Machine Learning*. Master's Thesis TFRT-6211. Supervisors: Thornberg, Tobias; Bhowmick, Surjit and Fänge, Thomas (external); Nardi, Luigi; Hvarfner, Carl; Giselsson, Pontus, Department of Automatic Control, Lund University.

Evaldsson, Isak and Paulcén, Henrik; *Estimating Ambient Temperature using Internal Sensors and Thermal Modelling in Mobile Phones*. Master's Thesis TFRT-6206. Supervisors: Möller, Richard and Olsson, Jimmy (external); Årzén, Karl-Erik and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Gabrielsson, Jonas; *Automatic testing of optical sight adjustment screws by a robotic arm*. Master's Thesis TFRT-6190. Supervisors: Andersson, Pontus and Rigestam, Lucas (external); Olofsson, Björn and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

Gassheld, Emory and Karlsson, My; *MPC for the Slow Orbit Feedback Control at MAX IV*. Master's Thesis TFRT-6197. Supervisors: Takahashi, Carla Caldeira; Sjöström, Magnus; Giselsson, Pontus and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Gulz-Haake, Sebastian and Karlbrink Malmquist, Nils; *Automation of High-accuracy Marking Tasks at MAX IV using the Quadrupedal Robot Spot.* Master's Thesis TFRT-6189, Supervisors: Andersson, Alina (external). Haage, Mathias; Olofsson, Björn; Robertsson, Anders and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Gustafsson, Amanda; *Towards individualised anaesthesia: A comparison between target-controlled infusion and closed-loop control*. Master's Thesis TFRT-6217. Supervisors: Wahlquist, Ylva and Soltesz, Kristian, Department of Automatic Control, Lund University.

Håkansson, Ludvig; *Optimization of Radiotherapy Treatment Plans Based on Monte Carlo Dose Computations*. Master's Thesis TFRT-6209. Supervisors: Landström, Eric (external); Giselsson, Pontus and Tegling, Emma, Department of Automatic Control, Lund University.

Hammar, Eric and Sjöstrand, Pontus; *Development of Detachable Audio Accessory for Surveillance Cameras*. Master's Thesis TFRT-6201. Supervisors: Wannebro, Linus and Sjöberg, Magnus (external); Olofsson, Björn and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Hässler, Anton; *Minimizing network utilization in event-triggered control of multi-agent system*. Master's Thesis TFRT-6159. Supervisors: Ristevski, Stefan and Bagge Carlsson, Fredrik (external); Laban, Lara and Soltesz, Kristian, Department of Automatic Control, Lund University.

Henningsson, Johan; *Local Planning for Unmanned Ground Vehicles using Imitation Learning*. Master's Thesis TFRT-6210. Supervisors: Bissmarck, Fredrik and Nordlöf, Jonas (external); Rantzer, Anders and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Horn, Fredrik; *Feedback Linearization for Model Agnostic Aircraft Simulation Control*. Master's Thesis TFRT-6219. Supervisors: Bernhardsson, Bo and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

Hosseini Nejad, Amin; *Developing an ML-based model for RF tuning of the DTL machine at ESS*. Master's Thesis TFRT-6193, Supervisors: Rathsman, Karin; Milas, Natalia (external); Johansson, Anders J and Bernhardsson, Bo; Grönqvist, Johan, Department of Automatic Control, Lund University.

Ivarsson, Celine and Zacke, Jennifer; *Night-time Vehicle Detection Based on Observable Light Cues Using Deep Learning*. Master's Thesis TFRT-6195. Supervisors: Fahlstad, Liam (external); Giselsson, Pontus and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Larsson, Filip and Hallqvist, Pontus; *Classifying Motion Patterns of Bikes using Machine Learning*. Master's Thesis TFRT-6192. Supervisors: Svensson, Anders (external); Karayiannidis, Yiannis and Giselsson, Pontus, Department of Automatic Control, Lund University.

Larsson, Patrik; *Designing and Implementing a Web Application for Bluetooth Mesh Device Provisioning and User Management*. Master's Thesis TFRT-6215. Supervisors: Wallinius, Mattias and Arvehammar, Maja (external); Årzén, Karl-Erik and Maggio, Martina, Department of Automatic Control, Lund University.

Lilja, Jonas; *Evaluating machine learning models for text classification*. Master's Thesis TFRT-6213. Supervisors: Cloarec, William (external); Eker, Johan and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Lundell, Erik and Molin, Gustav; *Energy-Efficient Fixed-Coefficient FIR Filters for Millimeter-Wave Radios*. Master's Thesis TFRT-6199. Supervisors: Troeng, Olof (external); Bernhardsson, Bo and Tegling, Emma, Department of Automatic Control, Lund University.

Monzó Martínez, Salvador and Zejnullahu, Altin; *Accuracy Improvement and Joint Stiction Relieve in Robot Arms Movement Applying Torque-Based Cartesian Impedance Control With Dithering*. Master's Thesis TFRT-6202. Supervisors: Mayr, Matthias; Salt Ducaju, Julian and Olofsson, Björn, Department of Automatic Control, Lund University.

Olsson, Alexander and Persson Caesar, Henrik; *Machine Condition Monitoring of Production Equipment*. Master's Thesis TFRT-6203. Supervisors: Sirbelius, Bengt (external); Kjellqvist, Olle and Soltesz, Kristian, Department of Automatic Control, Lund University.

Olsson, Johan; *Scalable Reinforcement Learning for Linear-Quadratic Control of Networks*. Master's Thesis TFRT-6207. Supervisors: Li, Na (external); Tegling, Emma and Rantzer, Anders, Department of Automatic Control, Lund University.

Olsson, Oscar Andreas; *Decision support in a volatile electricity market: forecasting and cost optimization*. Master's Thesis TFRT-6208, Supervisors: Tegling, Emma and Pates, Richard, Department of Automatic Control, Lund University.

Persson, Alexander; *PTZ Handover: Tracking an object across multiple surveillance cameras*. Master's Thesis TFRT-6216. Supervisors: Bibby, Paul Steneram and Ekman, Kenneth (external); Karayiannidis, Yiannis and Eker, Johan, Department of Automatic Control. Lund University.

Schyllert, Eric; *Dynamic Torque Control of Brushed DC Motors for Hardware-in-the-Loop Integration*. Master's Thesis TFRT-6220, Supervisors: Warnquist, Eric and Byrhult, Per (external), Cervin, Anton and Årzén, Karl-Erik, Department of Automtic Control, Lund University.

Spångberg, Carl; *State of Health estimation of battery systems*. Master's Thesis TFRT-6214: Supervisors: Pinter, Zoltan Mark; Papageorgiou, Dimitrios and Zhao, Chunyang (external); Pates, Richard and Olofsson, Björn, Department of Automatic Control, Lund University.

Svedberg, Markus; *Data-Driven Adaptive Control of Unmanned Surface Vehicles Using Learning-Based Model Predictive Control*. Master's Thesis TFRT-6205. Supervisors: Wingqvist, Birgitta; Olofssson, Björn and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Tanveer, M Asjid; *Deep convolution neural network for attention decoding in multi-channel EEG with conditional variational autoencoder for data augmentation*. Master's Thesis TFRT-6194. Supervisors: Alickovic Emina and Skoglund, Martin (external); Bernhardsson, Bo and Giselsson, Pontus, Department of Automatic Control, Lund University.

Warnström, Gustav and Fant, Johan; *Forecasting of Heat Pump Power Consumption using Neural Networks*. Master's Thesis TFRT-6191. Supervisors: Madjidian, Daria (external); Pates, Richard and Tegling, Emma, Department of Automatic Control, Lund University.

SEMINARS AT THE DEPARTMENT

January

16 Master's Thesis Presentation: : *Automation of high-accuracy marking tasks at MAX IV using a quadrupedal robot*, Sebastian Gulz-Haake and N Karlbrink Malmquist LTH.

17 Licentiate defence: *Human-Robot Collaboration for Kinesthetic Teaching*, Julian Salt Ducaju, LTH. Opponent: Dr. Mikael Norrlöf, Docent, Automatic Control, ABB Robotics.

17 Seminar: *Optimized control strategies for a large-scale industrial districtheating prosumer*, Ulrich Trabert, University of Kassel, Institute of ThermalEngineering.

Febuary

17 Master's Thesis Presention: *Evaluating machine learning models for text classification - A comparative study of Amazon Comprehend & Amazon SageMaker*, Jonas Lilja, LTH.

23 Seminar: *On the Fundamental Limits of Learning to Control*, Ingvar Ziemann, KTH.

March

01 Master's Thesis Presentation: *Classifying Motion Patterns of Bikes using Machine Learning*, Filip Larsson and Pontus Hallqvist, LTH.

07 Seminar: *Feedback system analysis: back to the future,* Rodolphe Sepulchre, KU Leuven and University of Cambrige.

14 Master's Thesis Presentation: *Minimizing network utilization in event-triggered control of multi-agent system*, Anton Hässler, LTH.

22 Seminar: *Decentralized Online Bandit Optimization on Directed Graphs with Regret Bounds*, Ather Gattami, AI Sweden, Stockholm.

23 Master's Thesis Presentation: *Developing an ML-based model for RF tuning of the DTL machine at ESS*, Amin Hosseini Nejad, LTH.

30 Licenciate defence: *On Hydraulic Constraints in Control of District Heating Systems,* Felix Agner, LTH. Opponent: Associate Professor Khalid Atta, Luleå University of Technology.

April

25 Seminar: *Edge Connected Drones for Autonomous Collision-Free Mission*, Achilleas Santi Seisa, Luleå University of Technology.

27 Seminar: *Online Learning for Control: Bringing Sequential Decision Making in the Loop*, Dr. Andrea Iannelli, University of Stuttgart (Germany).

28 Master's Thesis Presentation: *Practical trial of Fiber Optical Gyroscope Unaided Inertial Navigation System*, Tim Djärf, LTH.

May

05 Master's Thesis Presentation: *Night-time Vehicle Detection Based on Observable Light Cues Using Deep Learning*, Celine Ivarsson and Jennifer Zacke LTH.

05 Seminar: *Dimension Reduction in Statistical Learning*, Magnus Fontes.

23 AI Nordic Powwow in Lund.

24 Master's Thesis Presentation: *Deep convolution neural network for attention decoding in multi-channel EEG with Conditional variational autoencoder for data augmentation*, Asjid Tanveer, LTH.

26 Master's Thesis Presentation: *Generative AI for Synthetic Data*, August Borna and Esaias Belfrage, LTH.

26 Master's Thesis Presentation: *Accuracy Improvement and Joint Stiction Relieve in Robot Arms Movement Applying Torque-Based Cartesian Impedance Control With Dithering*, Altin Zejnullahu and Salvador Monzó Martínez, LTH.
29 Master's Thesis Presentation: *MPC for Slow Orbit Feedback Control for the MAX IV Accelerators*, Emory Gassheld and My Karlsson, LTH.

June

07 Master's Thesis Presentation: *Development of Detachable Audio Accessory for Surveillance Cameras*, Eric Hammar and Pontus Sjöstrand, LTH.
07 Master's Thesis Presentation: *Decision support in a volatile electricity market: forecasting and cost optimization*, Andreas Olsson, LTH.
07 AI Lund Lunch Seminar: *Path planning and way-point following for autonomous UAV missions using low-level control*, Lara Laban, LTH.
07 Seminar: *Beyond quantization: beating the encoder precision in motion systems*, Dr. Aurélio T. Salton, Federal University of Rio Grande do Sul, Porto Alegre, Brazil.
08 Master's Thesis Presentation: *Machine Monitoring of Production Equipment*, Alexander Olsson and Henrik Persson Caesar, LTH.
08 Master's Thesis Presentation: *Estimating Ambient Temperature using Internal Sensors and Thermal Modelling in Mobile Phones*, Henrik Paulcen and Isak Evaldsson, LTH.
08 Master's Thesis Presentation: *Radiotherapy Optimization Based on Monte Carlo Simulation*, Ludvig Håkansson, LTH.
08 Master's Thesis Presentation: *Designing and Implementing a Web Application for Bluetooth Mesh Device Provisioning and User Management*, Patrik Larsson, LTH.
09 Master's Thesis Presentation: *Energy-Efficient Fixed-Coefficient FIR Filters for Next-Gen mmWave Radios*, Erik Lundell and Gustav Molin, LTH.
09 Doctoral Defence: *Analysis of Embedded Controllers Subject to Computational Overruns*, Nils Vreman. Opponent: Professor Samarjit Chakraborty, University of North Carolina, USA.
12 Master's Thesis Presentation: *PTZ Handover: Tracking an object across multiple surveillance cameras*, Alexander Persson, LTH.
12 Seminar: *Dual Control for High Levels of Automation in Uncertain Environments*, Prof. Wen-Hua Chen, Loughborough University, UK.
12 Seminar held by Yuchao Li, KTH.
15 Master's Thesis Presentation: *Enhancing GNSS Precision for Mobile Devices with Sensor Fusion Techniques: A Case Study on eBike Tracking Using State Estimation*, Richard Byström and William Sjödin, LTH.
15 Master's Thesis Presentation: *Machine Learning for Unmanned Ground Vehicles*, Johan Henningsson, LTH.
15 Master's Thesis Presentation: *Model Agnostic Aircraft Sizing and Performance Simulation using Feedback Linearization*, Fredrik Horn, LTH.
19 Master's Thesis Presentation: *Data-Driven Adaptive Control of Unmanned Surface Vehicles Using Learning-Based Model Predictive Control*, Markus Svedberg, LTH.
19 Master's Thesis Presentation: *Hardware Door Simulator*, Eric Schyllert, LTH.
28 Seminar: *Nash equilibria of the pay-as-bid auction game with K-Lipschitz supply function*, Martina Vanelli.
29 Seminar: *Reinforcement learning for flexible building energy management*, Marco Biemann.
29 Seminar: *On the existence of equilibria in complex nonlinear network*, Mark Jeeninga.

August

24 Seminar: *Modeling the immune system from protein interaction to population dynamics,* Jonathan Desponds, Institut Roche, Paris.

25 Master's Thesis Presentation: *Scalable Reinforcement Learning for Linear-Quadratic Control of Networks*, Johan Olsson, LTH.

September

06 Master's Thesis Presentation: *Estimation of Microwave Antenna movements using Sensor Fusion on IMU and RSSI measurements*, Nikhil Challa, LTH.

07 Seminar: *How I ended up delivering takis in Dallas*, Erik Möllerstedt, Aurora, USA.

08 Licentiate defence: *Transient analysis and control for scalable network systems*, Jonas Hansson. Opponent: Bart Besselink, University of Groningen.

October

03 Master's Thesis Presentation: *An Analysis of the Effects of Persistent Noise on Distributed Averaging*, Hans Johansson Elmér, LTH.

10 Seminar: *Automatic control of general anesthesia: new developments and clinical experiments*, Dr. Michele Schiavo, University of Brescia, Italy.

13 Licentiate defence: *On Calibration Algorithms for Real-Time Brain-Computer Interfaces*, Frida Heskebeck, LTH. Opponent: Elaine Åstrand, Mälardalens högskola.

24 Seminar: *Beyond the hype: Useful aspects of AI, Industrie 4.0 and the Digital Twin*, Margret Bauer.

November

23 *Robotics Cognition and Automation* - a robotics week seminar and lab tour.

24 Doctoral Thesis Defence: *Learning to Control the Cloud*, Albin Heimerson, LTH. Opponent: Professor Ivona Brandic, Vienna University of Technology, Austria.

30 Master's Thesis Presentation: *Using synthetic data for object detection on the edge*, Faraz Azarnoush and Damil Sabotic, LTH.

December

01 Seminar: *Stealthy False Data Injection Attacks in Feedback Systems Revisited*, Henrik Sandberg, KTH.

External Engagement

Collaborations with both academia and industry

Together with external contacts and partners the goal is to solve real control problems. A mix of fundamental and applied work constitutes a cornerstone of our activities. In these kinds of projects the problems are approached with an open mind. One motivator is to solve real-world problems, another is to learn about new problems that can inspire theoretical research. An important role for universities is to organise knowledge in such a way that it can easily be digested by engineers in industry. One way to reach out is through our Industry Club.

During the year we have had collaborations with a large number of different organizations in academia and industry, both domestically and internationally. We are very happy for all collaborations and proud to have a large and stable network. This enables us to expand our research horizon and to be an important partner in future projects. Here follows three examples.

HONORARY DOCTOR

In 2023 Lund University, Faculty of Engineering had three honorary doctorates. Professor Ikhlaq Sidhu has a long and prosperous collaboration with Professor Charlotta Johnsson at Department of Automatic Control, and at LTH's MakerSpace X-Lab. The collaboration started in 2013 when Charlotta spent a sabbatical year at UC Berkeley, and it has continued ever since. It has resulted in several publications and collaboration projects in the area of engineering, innovation and entrepreneurship.

Ikhlaq Sidhu is Dean of the School of Science and Technology, IE University in Madrid. He has previously started the University of California Berkley's Sutardja Center for Entrepreneurship & Technology. He has several previous collaborations with LTH and LTH has a program based on his work on "entrepreneurial mindset". The decision also emphasizes that he can contribute to the development of LTH's innovation capacity and that he has a strong international network of contacts.

Professor Ikhlaq Sidhu

COLLABORATION WITH UKRANIAN SCIENTIST

When the full scale war between Ukraine and Russia started in February 2022, many left the country to find a safer place. Most of them ended up in the countries closest to Ukraine, but some came to Sweden.

With financial support from the Wallenberg Foundation, we welcomed Volodymyr Voitenko to the Automatic Control Department in Lund. Here he could continue doing research as well as teaching his students at the University in Chernihiv, but now remotely. Lectures and exams - all performed on remote. Even attending a conference was made possible.

A year passed and the situation in Ukraine has not changed. Additional funding from Crafoord Foundation and SAR (Scholars at Risk) made it possible to extend his stay in Sweden and the department. SAR is a network for protecting academic freedom which enables asylum for researchers at a university outside their native country.

Volodymyr Voitenko, researcher

INDUSTRY CLUB

The Industry Club, which stands for Exploring, Expanding and Applying Control Technology, is an initiative to build an ecosystem around the Department of Automatic Control at Lund University. We have created this as a way to share ideas and get feedback on the research we do. We want to reach out to the industry and other organizations to collaborate on new projects and initiate new research questions. The interface of the Industry Club will be a recurring newsletter, where we will present interesting new developments at our department, report about advances in the field of automatic control, as well as opportunities for collaborations, but also a webpage, online and live events.

We have many collaboration activities with external partners. A common form is through master's thesis projects where we interact with both small start-ups and large companies and organizations. We also have a set of larger projects, often including industrial PhD students, with companies like SAAB Kockums, Ericsson and Boliden, where we work together on more long-term challenges. We also work closely with our spin-off companies, e.g., Modelon and Cognibotics, to bring research results to the market. Through our participation in large Swedish industry-academic research programs, such as the strategic research environment ELLIIT and the Wallenberg-funded WASP organization, we work closely with other leading Swedish universities. These collaborations give us and our partners great opportunities for technology transfer, both from theory to applications, as well as between different application domains.

From Spring 2024 the Industry Club will be integrated with the ELLIIT Industry Forum. In addition a separate Automatic Control Alumni Newsletter will be created.

Economy

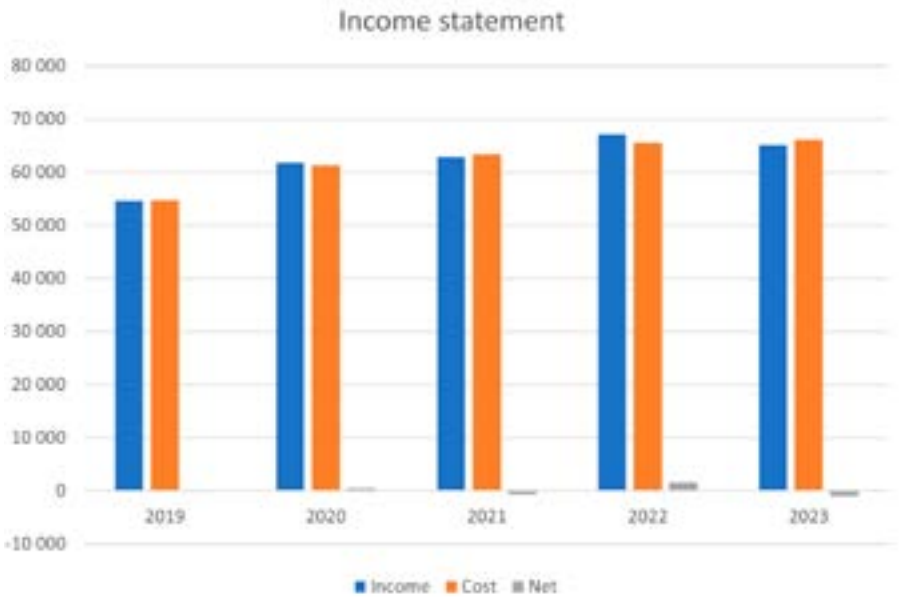
This chapter contains an overall view of the economy and funding

ECONOMY

The turnover for 2023 was 65,1 MSEK, a decrease of 2,0 MSEK compared to 2022. About half of the income comes from Lund University and the remaining half from external grants. We made a deficit of 1,0 MSEK and have an Agency capital of 9,7 MSEK.

Today the number of employees are now stable at the level of around 60 people. The number of employees corresponds to 51 full-time equivalent. Substantial support of our different activities have been provided by the European Union Horizon 2020 programme, Swedish Research Council (VR), Knut and Alice Wallenberg Foundation (KAW) and Swedish Government Agency for Innovation Systems (Vinnova). ELLIIT has grown and we have been successful in receiving funding for both new PhD and Postdoc positions.

The block grants from VR, KAW and ELLIIT are long range. Some projects do, however, have shorter duration such as three years or less. To match these with the length of a PhD position, normally for 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

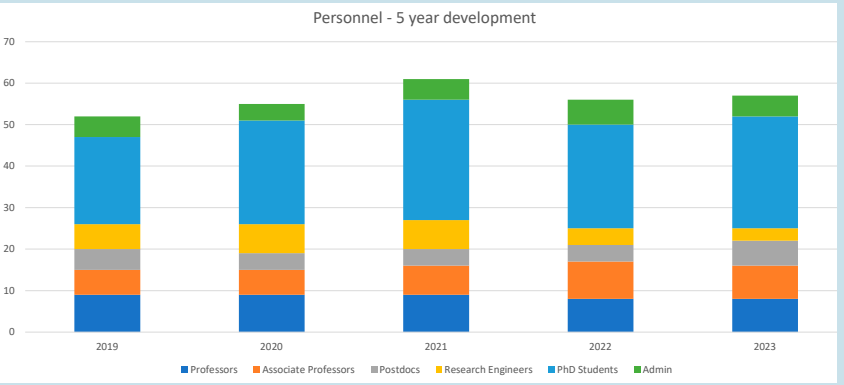
During 2023 we had the following external grants:

VR – Fundamental mechanisms for scalable control of large networks
VR – A Framework for MPC Stability Analysis
VR – Statistical Learning Theory for Safety-Critical Control: Fundamental Limits and Optimal Algorithms
Vinnova – SelectiCa (cofunding EU Horizon 2020)
Vinnova – Advanced Offloading for Real-Time Applications (AORTA)
Vinnova – Advanced Driver Support System for Micro Mobility Vehicules
EU Horizon 2020 – Scalable Control of Interconnected Systems - an ERC project
EU Horizon 2020 – Admorph Towards Adaptively Morphing Embedded Systems
KAW – Wallenberg AI, Autonomous Systems and Software Program (WASP)
KAW –DDLS
KAW – WASP NEST
KAW – WASP WARA
KAW – Support of ukrainian scientist
ELLIIT – Robust and Secure Control over the Cloud
ELLIIT – Autonomous Force-Aware Swift Motion Control
ELLIIT – Scalable Optimization for Learning in Control
ELLIIT – Visual Feature Based Data Reduction
ELLIIT – Dynamics of complex socio-technological network systems
ELLIIT – Recruitment of an Associate Professor in Robotics
ELLIIT – Infrastructure Robotics
ELLIIT – Optimal estimation and control at scale
ELLIIT – Visual analytics of large and complex multilayer technological networks
ELLIIT – Integrated reactive motion planning and motion control
NordForsk – Nordic University Hub on Industrial Internet of Things (HI2OT)
Mats Paulsson Foundation - Funtional ex vivo heart evaluation
IFAC Activity Fund
The Hjelm Family Foundation - Functional ex vivo heart evaluation
The Crafoord Foundation

Personnel

In this chapter the personnel and their activities are described


HOTELL
SMYGEHUS


Personnel - 5 year development
70
60
50
40
30
20
10
0
2019
2020
2021
2022
2023
Professors
Associate Professors
Postdocs
Research Engineers
PhD Students
Admin

Professor Emeritus
Åström, Karl Johan
Hagander, Per
Hägglund, Tore
Johansson, Rolf
Wittenmark, Björn

Professors
Årzén, Karl-Erik, deputy head of department
Bauer, Margret; Lise Meitner professor (20%)
Bernhardsson, Bo
Eker, Johan (50%)
Fontes, Magnus (20%), adjunct professor
Johnsson, Charlotta
Maggio, Martina (20%)
Rantzer, Anders; head of department

Associate Professors
Cervin, Anton (on leave 2023)
Como, Giacomo (25%)
Giselsson, Pontus, director of graduate studies
Karayiannidis, Yiannis
Olofsson, Björn (70%), director of undergraduate studies
Pates, Richard
Soltesz, Kristian
Tegling, Emma

Research Engineers
Blomdell, Anders
Nilsson, Anders
Pisarevskiy, Alexander

Administrators
Edelborg, Cecilia
Nishimura, Mika
Rasmusson, Monika (70%)
Westin, Eva
Wisbrant, Jonas

Postdocs
Govaert, Alain (until August)
Jeeninga, Mark (from September)
Renganathan, Venkatraman
Sundell, Jesper
Ziemann, Ingvar (from March)
Wu, Dongjun

Researchers
Banert, Sebastian (until June)
Voitenko, Volodymyr

PhD Students
Adlercreutz, Julia
Agner, Felix
Al-Bayati, Ahmed (from August)
Akerman, Anton (from August)
Bakovic, Luka
Bencherki, Fethi
Gemborn Nilsson, Martin
Grönqvist, Johan
Guberina, Marko
Gurpegui Ramón, Alba
Hansson, Jonas
Heimerson, Albin (until December)
Heskebeck, Frida
Jia, Zheng
Kjellqvist. Olle
Laban, Lara (LU School of Aviation)
Lindberg, Johan
Nauta, Talitha (from September)
Nilsson, Max (from January)
Nyberg Carlsson, Max
Ohlin, David
Pigot, Henry
Salt Ducaju, Julian
Sinnema, Yde (from September)
Sundstrom, Emil (from November)
Upadhyaya, Manu
Vladu, Emil
Wahlquist, Ylva

Industrial PhD Students
Norlund, Frida; Boliden AB
Stoltenberg, Peter; Saab Kockums AB (from Oct)
Tufvesson, Pex; Ericsson
Wingqvist, Birgitta; Saab Kockums AB

Assistant Research Engineer
Stenberg, Oscar (20%) amanuens

Tore Hägglund

The latest Professor Emeritus at the Control Department

Tore Hägglund

Tore has had a long and successful career, mostly at the department, but not only as a brilliant researcher and teacher. He has also been in formal administrative roles. For example Head of the department – twice, deputy head of the department – three times, which includes everything from strategic decision and finances to inaugurations, celebrationsand sending off colleagues to retirement. He has developed and kept developing course material over the years and the colleague, taking over the course recently said: "– I've spent a summer reading the material. I so much enjoyed it! I realized; it is perfect, it can not be improved!"

He defended his thesis in 1984 and went out to industry, to Satt Control Instruments (now ABB), but was lured back after a few years and was hired as assistant professor in 1989.

Ten years later he became full Professor and furthermore Professor emeritus in 2022. A clever move from the department was to involve Tore in the organization of the department move on campus – in that way we got to keep him for another year.

Tore continued to work with industry and industrial problems. From time to time Tore would have a big smile on his face saying:

– I am leaving for Grums or Kiruna. This meant that he would go to teach, to tune, to analyze for a few days – hands on together with engineers on the floor – and we would then read about the success of Tore.

During his career as researcher, Tore has:

- written numerous books (5) and book chapters (7), journal articles (80) and conference papers (85).

- supervised and co-supervised a large number of licentiate (7) and doctoral theses (10).
- organized many events within the field of PID, adaptive control, self tuning
- been responsible for introducing control engineering to the students of the Faculty of Engineering (LTH) and over the years he has taught the Control, basic course to around 10 000 students!
- been awarded ETP (Excellent Teaching Practitioner)
- holds a number of patents, used widely in industry

Tore is a practical man who is engaged, competent, organized and experienced. You will often hear:

– let's ask Tore, he will know what to do, what to say, where to look, how to solve the problem.

He has a great sense of humour and never says no to games or practical jokes.

He is also approachable, generous, empathetic and a very good listener. As one PhD student said:

– Tore is unique, it will be very difficult to replace his way of listening in such a caring, engaged way.

Above all Tore is a beautiful person and colleague and he has spread and will continue to spread knowledge, enthusiasm and joy not only in Lund but wherever he sets his foot.

LONG-TERM VISITORS

La, Mi, University of Luxemburg, postdoc, June-November
Lee, Bruce, University of Pennsylvania, PhD student, September-October
Monguzzi, Andrea, Politecnico di Milano, Italy, until February
Trabert, Ulrich, Kassel university, PhD student, February-April
Wengel Mogensen, Søren, Copenhagen University, postdoc

BOARD OF THE DEPARTMENT

Anders Rantzer
Karl-Erik Årzén
Charlotta Johnsson
Martina Maggio
Kristian Soltesz
Björn Olofsson
Yiannis Karayiannidis
Richard Pates
Venkatraman Renganathan
Monika Rasmusson
Anders Nilsson

Johan Lindberg
David Ohlin

ACTIVITIES OF PERSONNEL

Agner, Felix
MSc Engineering Physics, LTH, 2019. PhD student since January 2020. Since March 2023 he has the degree Licentiate as he successfully defended his thesis *On Hydraulic Constraints in Control of District Heating Systems*.

His research interests are Scalable control for energy systems under Anders Rantzer's ERC funded project in scalable control, focusing on district heating systems. The focus is to create control coordination strategies between agents such as buildings that increase system-level benefits while being minimally intrusive in terms of communication and additional measurements.

During the year he has developed labs and taught in the course *Learning Based Control*, as well as supervised projects in the project course. Additionally, he has supervised the MSc project *Using synthetic data for object detection on the edge in Hazardous Environments*.

Adlercreutz, Julia
MSc in Engineering Physics 2022 at LTH. PhD student since August 2022.

Her main research area is structured optimal control for large scale systems. She is supervised by Richard Pates and is funded by ELLIIT.

During the year she has been a teaching assistant in the course in *Real-Time Systems*, and in the course *Automatic Control, Advanced Course*.

Åkerman, Anton
MSc in Engineering Mathematics, LTH, 2023. PhD student since August 2023.

His current research is on convergence for a certain type of first order methods.

He has been a teaching assistant in the *Optimization for learning* course and in the *basic control* course.

Al-Bayati, Ahmed
PhD student at the department since August 2023, with a keen interest in offloading and cloud computing.

This year, he focused on his MSc thesis, aiming to control a Furuta pendulum by offloading the MPC optimization algorithm to the Edge, compiling the code to WebAssembly (Wasm).

In terms of teaching, he had the enjoyable experience of instructing his first course, the *basic control course*. Additionally, he achieved a personal milestone by obtaining his motorcycle driving license.

Årzén, Karl-Erik
Professor (2000), PhD (1987), joined the department in 1981.

His research interests are real-time and embedded control, real-time systems, cloud control, feedback computing, autonomous systems, and programming languages for control.

Coordinator for the Lund part of WASP (Wallenberg AI, Autonomous Systems and Software Program). WASP co-director for research program coordination. Chair of the Research Management Group of WASP. Member of the WASP Executive Committee.

During the year he has primarily been involved with WASP, ELLIIT and the Nordforsk University Network HI2OT.

He is partly or fully involved in the supervision of three PhD students.

Bakovic, Luka
MSc in Automatic Control, received in 2021 from the University of Zagreb. PhDl student at the department since 2022.

He research interest is in the area of opinion dynamics and socio-technical systems, supervised by Emma Tegling and Giacomo Como.

He has been involved in teaching the courses *Applied Robotics*, *Learning-Based Control* and *Network Dynamics*.

Bauer, Margret
Margret Bauer received her undergraduate degree in electrical engineering from the University of Erlangen-Nuremberg in 2001. She is professor at Hamburg University of Applied Sciences in Germany, and is one of few women in automatic control.

In 2021 she was nominated for the Lise Meitner Professorship at the Department of Automatic Control, LTH, and is now working part-time in Lund.

Her research interest is on data analytics and big data for process control.

Bencherki, Fethi
MSc in control systems in 2020 from Eskisehir Technical University, Turkey. PhD student at the department since Aug 2020. He is supervised by Anders Rantzer and Emma Tegling.

Fethi is within the WASP-NEST project and his research interest revolves around developing scalable control approaches for large scale networks. He is also interested in learning-based control and the identification of switched systems.

Teaching Assignments for 2023 included the *Basic Control course* and *Nonlinear Control and Servo Systems*.

Bernhardsson, Bo
PhD 1992, Professor since 1999, has also worked at Ericsson 2001-2010 as an Expert in Mobile System Design and Optimization. Since 2020 he is one of the Master Programme Directors for the new international masters program in *Machine Learning, Systems and Control*.

Bo's main current research interest is in statistical learning and control with applications on EEG signals and BCI systems.

During 2023 he taught the course "Modeling and Learning from Data" for about 60 students and together with Patric Jensfelt at KTH and Gustaf Hendeby at LiU he also held the WASP PhD course in Autonomous Systems for about 40 students from 6 universities.

He is part of the profile areas *Engineering Health* and *AI and Digitalization,* LTH, as well as part of profile area the *Natural and Artificial Cognition,* LU.

He is the main supervisor of 4 PhD students within this area and co-supervisor of 5 PhD students. He is also responsible for the coordination of our master thesis projects at the department.

Blomdell, Anders
Research Engineer at the department since 1988.

Responsible for the department network and lab computers for teaching and research. Started to catch up on all stuff that was neglected due to all extra work induced by the M-house rebuilding.

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.

His research interests are in Dynamics, Information, and Control in Networks, with applications to transport, infrastructure, as well as social and economic systems.

During 2023, he has served as co-supervisor of Luka Bakovic, LTH and as supervisor of Martina Vanelli, Sebastiano Messina, Alexia Ambrogio, Leonardo Cianfanelli and co-supervisor of Martina Alutto, and Roberta Raineri at Politecnico di Torino.

In Spring 2023, he taught the master level course *Network Dynamics.*

During 2023, he has partly been on leave at Politecnico di Torino.

Edelborg, Cecilia
Cecilia is the Financial and HR administrator at the department since 2017.

She is responsible for accounting, for travel expenses, intermittent employments, reimbursements, invoices, and projects. She also handles parts of human resources as well as guests and conferences and as a registrar and purchasing coordinator at the department.

Cecilia is a part of the group for gender and equality issues at LTH.

Her background is from the Faculty of Law, Lund University.

Eker, Johan
Johan is Professor (50%) and also holds a position as Principal Researcher at Ericsson Research (50%). He received his PhD in Automatic Control from Lund Univer sity in 1999 and subsequently joined the Ptolemy group at UC Berkeley. He was appointed adjunct Professor in Automatic Control, Lund University in 2013 and became full Professor in 2023.

His research interests includes methods and programming languages for parallel systems, real-time control systems, data-driven operation and cloud computing technologies. He is the co-designer of the CAL Actor Language, which is part of the MPEG standard ISO/IEC 23001-4:2011. He holds over 80 granted patents in the areas of telecom, IoT and cloud computing. He is involved in the operation of the Ericsson Research Data Center and works with industrial cloud applications and data-driven systems.

He is participating in a range of program committees and research projects on topics such as real-systems, signal processing, software development, cloud technology, brain-computer interfaces, and AI.

Johan is leading the WASP research arena on data-driven operations called WARA-Ops.

Johan is the main supervisor for Emil Sundström and co-supervisor for Pex Tufvesson, Frida Norlund, Max Nyberg Carlsson and Ahmed Albayati.

Gemborn Nilsson, Martin
MSc in Electrical Engineering 2020. PhD student at the department since January 2021.

Supervised by Bo Bernhardsson and funded by ELLIIT, his research project mainly concerns representation, visualization, and classification of EEG signals for improved efficiency of Brain-Computer Interfaces.

During the year, Martin has been a TA in the following courses: *Modeling and Learning from Data*, and the *Basic Course in Automatic Control.*

Giselsson, Pontus
Pontus has been serving as an Associate Professor in the Department of Automatic Control since 2017, after holding an Assistant Professor position. He earned his MSc degree from Lund

University in 2006 and completed his PhD at the Department of Automatic Control, Lund University in 2012. Pontus was awarded the title of Reader (Docent) in 2018.

His research primarily focuses on optimization and its wide range of applications.

In 2023, he taught the undergraduate courses in *Optimization for Learning, Systems Engineering*, and *Process Control*. Pontus supervised numerous Master's thesis projects, guided three PhD students, and mentored a postdoctoral researcher.

Additionally, he is the director of doctoral studies at the department.

Grönqvist, Johan

PhD (Physics), 2010, LTH and PhD student at the department since 2019.

His general control interest are Learning, and Robustness. He is trying to obtain Guaranteed closed loop properties with Neural Networks.

He has participated in the project AI for Guidance, Navigation and Control (AI4GNC),

Johan has been supervising a Master's thesis for Amin Hosseini Nejad, working with the ESS, Developing an ML-based model for RF tuning of DTL machine.

Guberina, Marko

MSc in Physics Engineering (Complex adaptive systems) 2022 at Chalmers. PhD student at the department since September 2022 and became WASP-affiliated in January 2023.

He is supervised by Yiannis Karayiannidis and Björn Olofsson and funded by ELLIIT.

His research interest is in robotic hand-arm coordination for robotic manipulation tasks. during the year he has been taking courses in robotics and control to further extend his knowledge. He has developed software infrastructure for the UR5e robot in the RobotLab and hopes to extend this library to other robots in the lab.

He has been taking on teaching assignments in the follwing courses during the year; *Applied Robotics* course, *Modelling course* and the *Project course* where the aforementioned newly developed software library was utilized.

He also developed a new demo and participated in Robot Week late November.

Gurpegui Ramón, Alba

MSc in Mathematics, Lund University. PhD Student at the Department of Automatic Control since end August 2022.

Alba is supervised by Anders Rantzer.

Her general research interests are within linear optimal control, positive systems and large scale systems.

She is also part of the NEST project. She was also organizing the PhD day together with Felix.

She has been a teaching assistant in the *Advanced Control course* and *Basic Control course*, which included responsability for exercise sessions and lab sessions and for the retake exam.

Hansson, Jonas

MSc in Engineering Physics, LTH, 2020. PhD student since August 2020.

Jonas' main interest pertain to the fundamental limitations in the Control of large-scale and networked systems, which is led by Emma Tegling with WASP funding. In particular he has investigated how heterogeneity impacts the spread of infectious diseases and methods for describing the transient behaviour of network dynamical systems. He has a special interest in multi-agent systems and the scalable control thereof.

In September, 2023 he presented his licentiate thesis *Transient Analysis and Control for Scalable Network Systems*.

Heimerson, Albin

MSc in Engineering Physics, LTH, 2018. PhD student since August 2018. He has been a PhD student at the Department of Automatic Control until November 2023 when he defended his thesis *Learning to Control the Cloud*, receiving his PhD.

Albins research interests are towards ML/RL, looking at when they can be beneficial compared to classical control. He is also interested in how to make learning based systems more efficient

by imposing structure from existing knowledge.

He has been master's thesis supervisor for Axel Andersson and Nils Hallerfelt.

Heskebeck, Frida

MSc in Biotechnology 2019, Lund University, Since August 2019 a PhD student and has a Licentiate degree in automatic control since 2023. She is working with Brain-Computer Interfaces (BCI) with a specific interest for the calibration of BCIs. She is part of the project Realtime Individualization of Brain Computer Interfaces.

Frida returned from her parental leave in April and has since presented her Licentiate thesis, titled *On Calibration Algorithms for Real-Time Brain-Computer Interfaces* in October. She has written two papers with Pex Tufvesson, presented at a conference on teaching, and been involved in teaching in the course *Physiological modelling*. She has also spent some time on course development for the courses *Systems engineering* and *Process control*.

Jeeninga, Mark

MSc in Mathematics (2015), PhD in Automatic Control (2021), both from the University of Groningen. Post-doc at Politecnico di Torino (2021-2023), and at the department since September 2023, hosted by Emma Tegling and Anders Rantzer.

His research interests include the analysis and control of network systems, power flow analysis, matrix and graph theory, district heating networks and vehicle platooning.

He has been on a three-week visting period at Linköping University in September, as part of the ELLIIT Focus Period on Network Dynamics and Control.

Jia, Zheng

MSc in robotics, systems, and control from ETH Zurich in 2017. Zheng started as a PhD student in September 2021 and has been a WASP affiliated PhD student since November 2021.

Zheng's research interests include force control, motion control and robotics.

Johnsson, Charlotta

Professor (2018), PhD (1999). Dean of Campus Helsingborg, Lund University (2021-) and Director of X-Lab, LTH (2020-).

Charlotta's main research interest covers Automation, Control and Operations. However, Charlotta is also involved in the research domains of Innovation and Entrepreneurship, Teaching and Learning in Higher Education, as well as Technology Management and Engineering Leadership.

She is the Chair of ISO TC184/SC5, hence actively working on development of standards for Smart Manufacturing and Industry 4.0. She is also the deputy director for the makerspace X-Lab at LTH, an open innovation space for both students and colleagues at LTH.

During the year 2023, Charlotta has been course responsible for the course *Projects in Systems control and Learning*. She has been a guest lecture in several master- and PhD-courses at Lund university, including *Automation in Complex Systems* (given by the Department of Biomedical Engineering), *Research Methodology, Ethics and Innovation* (Dept of Computer Science), and *Innovation and Value Creation in Research* (Dept of Design Sciences). Charlotta has also given invited seminars to industry focusing on Industry 4.0/Smart Manufacturing.

Karayiannidis, Yiannis

He received a Diploma in Electrical and Computer Eng. and a PhD degree in Electrical Eng. from Aristotle University of Thessaloniki, Greece, in 2004 and 2009, respectively and became Reader (Docent) at Chalmers University of Technology in 2017. He was affiliated with KTH, Royal Institute of Technology (2011-2020) and Chalmers University of Technology (2015-2022). Associate Professor at the Department of Automatic Control in August 2022. He is a WASP-affiliated faculty member and, currently, a supervisor of two WASP funded PhD students. In 2023, he has also been appointed as co-Director of the RobotLab LTH.

His research interests include robot control and manipulation, robot navigation, haptic perception, physical human-robot interaction, adaptive control and nonlinear control systems. He is currently focusing on force-based robot control and perception, manipulation of deformable objects, contact modeling for manipulation and dynamic trajectory generation for robotic systems under constraints.

During 2023, Yiannis was responsible for the undergraduate level courses in *Nonlinear Control and Servo Systems* and *Mathematical Modeling*. He supervised three master projects and one Phd student working on hand-arm coordination at the Department of Automatic Control. He is a co-supervisor of two Phd students at the Department of Automatic Control but also the main supervisor of three Phd students affiliated with Chalmers University of Technology.

Kjellqvist, Olle
MSc in Engineering Physics from Lund University in 2018. Olle is a PhD student since 2019, and received his Licentiate degree in automatic control in 2022.

Olle is active in the *Learning and Adaptation* and *Scalable Control of Interconnected Systems* projects, and his research interests include learning-based control, dual control, adaptive control and large-scale systems.

This year, he has assisted in the teaching of *Real-Time systems* and *Project in Systems, Control and Learning* and supervised two students, Alexander Olsson and Henrik Caesar, in successfully completing their master's thesis project: *Machine Condition Monitoring of Production Equipment*.

Laban, Lara
MSc in Mechanical Engineering (Automatic Control with a focus on Computer Vision), at the University of Belgrade, Serbia. PhD student at the department since April 2022. She is supervised by Rolf Johansson and Björn Olofsson from the Department of Automatic Control, with Lund School of Aviation (LUSA) funding and co-supervision of Johan Bergström and Rikard Tyllström. This project is a collaboration between Lund University School of Aviation and the Department of Automatic Control (UAS@LU).

Her research topic: A research platform will be developed to demonstrate autonomous flight missions in an air traffic control environment with mixed autonomous, civil and military aviation under supervision of air traffic control (ATC). The research will focus on different aspects of autonomous flight, e.g., planning and control.

Lindberg, Johan
MSc in Engineering Physics (2020) and started as a PhD student at the department in September 2020.

His supervisor is Richard Pates and he works with scalable, decentralized control.

Johan's research interests are towards how decentralized control can be used in the electrical power grid. Especially how to keep it in balance when more power production comes from renewables, that are less predictable than traditional power production, and where the power is injected to the power grid through power electronics, instead of traditional synchronous machines.

During 2023 Johan wrote his Licentiate thesis titled *On H2 and H-infinity Optimal Control of Mass-Spring Networks with Power System Applications* presented in December 2023. He was also a teaching assistant in the bachelor course *Automatic Control, Basic Course*.

Maggio, Martina
PhD, 2012, Politecnico di Milano. She completed her Ph.D. at Politecnico di Milano, working with Alberto Leva on the applications of control-theoretical tools for the design of computing systems. During her Ph.D., she spent one year as a visiting graduate student at the Computer Science and Artificial Intelligence Laboratory at MIT, working with Anant Agarwal and Hank Hoffmann on the Self-Aware Computing project.

She joined Lund University in 2012 as a postdoctoral researcher, working with Karl-

Erik Årzén on resource allocation for cloud infrastructures and real-time systems. Martina became an Assistant Professor in 2014, and then Docent and Associate Professor in 2017. In 2019, she spent a sabbatical year at Bosch Corporate Research in Renningen, Germany, working with Dirk Ziegenbein and Arne Hamann on the verification and validation of control systems in presence of deadline misses and computational faults. Martina is now a Professor at the Computer Science Department, Saarland University since March 2020 and at the Department of Automatic Control, Lund University since 2023.

Nauta, Talitha
MSc in Engineering Mathematics 2023 at LTH. PhD student since September 2023.

She is supervised by Martina Maggio and is funded by WASP.

Her main research interests are on real-time control systems, with focus on security and cyberattack detection.

In 2023 she has been a teaching assistant in *Automatic Control, Basic Course*.

Nilsson, Anders
PhD (2006), Research Engineer since 2010.

Spends most of the time looking after the department computers and their software. He also spends some time maintaining and developing the robotics lab.

Nilsson, Max
MSc in Computer Science and Engineering, 2022, Lund University and he is a PhD student since January 2023.

Max research interests are in continuous optimization and its applications. Currently, his focus is first order Bregman optimization methods, for convex and relatively smooth optimization problems. His work on the symmetry coefficient of Legendre functions was presented at the conference EUROpt 2023, Budapest.

During 2023 he has been a TA for *Optimization for Learning* and lab responsible for *Modeling and Learning from Data* and also leading the PhD-course *Pragmatic Programming*.

Nishimura, Mika
Born in Japan. Administrator at the department since January 2014.

She handles Ladok (student administration system) for both students and PhD students. She has contact with the printing office about publications, and is responsible for purchase of office supplies, books and handles Lucat-catalogue system for the employees at the department. In addition, she reviews Lucris-research portal, updates LUP-student paper and parts of the web pages as well as other service-oriented tasks.

Norlund, Frida
Frida obtained her MSc in Engineering Physics from Lund University, 2022. Since September 2022 she is an industrial PhD student at the department.

She is employed by Boliden AB and her research interests are within data driven modeling and control of the flotation process.

Nyberg Carlsson, Max
MSc in Engineering Physics (2021) at LTH. PhD student since August 2021 as a part of an ELLIIT funded project. WASP affiliated as a part of class 2022.

Research interests include real-time systems and how the "infinite" resources from cloud computing can be exploited in a robust way.

Partook in creating a Julia port of the JitterTime toolbox.

Teaching duties during 2023 were *Real-Time Systems* in the spring and *Automatic Control, Basic Course* in the fall.

Ohlin, David
MSc Engineering Physics (2021), LTH. PhD student since 2021, supervised by Emma Tegling. Part of the WASP NEST project Learning in Networks: Structure, Dynamics, and Control.

His current research focuses on scalable optimal control of positive networks. Other interests include the modeling of opinion dynamical systems as nonlinear positive networks.

Teaching responsibilities in 2023 were comprised of two masters-level courses;

teaching assistance and course development of *Learning-Based Control* and teaching assistance in *Network Dynamics*.

Olofsson, Björn

MSc in Engineering Physics in 2010 and the PhD in Automatic Control in 2015, both from Lund University, and was appointed Docent at Linköping University in 2020. He has been with the department since 2010. He is since May 2022 a Senior Lecturer and since November 2022 Director of Undergraduate Studies.

Björn has broad research interests in motion planning and control for autonomous robots and vehicles. During the year, he has been involved in research projects within the ELLIIT Strategic Research Area, the Wallenberg AI, Autonomous Systems and Software Program, and a collaboration project with the School of Aviation at Lund University.

He has taken active part in the teaching activities at the department. He was responsible for the course *Applied Robotics* during the fall semester.

He was also acting as supervisor and examiner of several Master's Theses during the year. He is the main supervisor of five PhD students and co-supervisor of one PhD student at the department. In addition he is co-supervisor of one PhD student at Dept. Computer Science, one PhD student at Dept. Architecture and Built Environment, and two PhD students at Division Vehicular Systems, Linköping University.

Pates, Richard

Richard received the M.Eng degree in 2009 and PhD degree in 2014, both from the University of Cambridge. He has been an Associate Professor in the Department of Automatic Control since 2020..

He has broad interests in automatic control, with a particular focus on the control of electrical power systems.

He is currently the main supervisor for two Ph.D. students and an assistant supervisor for another two.

In addition, in the academic year 2022-2023, he supervised a range of master's thesis projects, taught the *Basic Course in Automatic Control,* the *Control Theory* course, the I*ntroduction to Machine Learning and Control* course, as well as two Ph.D. courses.

He additionally took on an editorial role with a focus on education for Control Systems Magazine.

Pigot, Henry

Henry (Harry) joined the department as a Project Assistant in 2018 and became a PhD student in 2019. He has an electrical engineering degree from the University of British Columbia in Vancouver, with a specialization in biomedical applications.

Harry's main interest is medical technology development. The focus of his thesis is applying control theory to improve the safety and efficacy of devices for evaluating heart organ function outside of the body. He works together with Kristian Soltesz, Ylva Wahlquist, and researchers at Igelösa Life Science AB.

In 2023, Harry continued the development of a new type of cardiac afterload designed to provide tighter control of organ evaluation for improved organ safety in transplantation. He presented the concept at the IFAC World Congress in Japan. Harry also wrote a book chapter providing a concise technical and methodological guide for a working heart model, detailing the experimental procedure using pig hearts and emphasizing the history and advancements in afterload devices. He helped with the development of the Physiological Modelling course. At X-lab, LTH's co-creation and innovation space, Harry continued as a member of the leadership group, taking responsibility for student engagement by coordinating a group of student volunteers and organizing workshops, including a hands-on introduction to PID control using a simple ball-and-beam process.

Pisarevskiy, Alexander
DipEng in Optoelectronics (2009). Research Engineer since 2020.

Mainly participates in upgrading of lab equipment for education processes.

During 2023 he has also worked on modernization of moving robotic platform "Sleipner", reorganization of work and storage areas during relocation of department and took part in several student projects.

Rantzer, Anders
Professor of Automatic Control since 1999 and head of department.

Anders is the main supervisor for several PhD students and postdocs.

He has broad interests in modeling, analysis and synthesis of control systems, with particular attention to uncertainty, optimization, scalability and adaptation.

During 2023, he also taught the masters level course named *Learning-based Control*.

Rasmusson, Monika
She joined the department in August 2011 and as from March 2017, she took over as finance officer and is now responsible for year-end closing, budget, forecast and reporting, both internallly within the faculty and externally to sponsors.

As a part of the administrative team, her work includes backup function for her colleagues, editing the yearly Activity Report, among other administrative tasks.

She is a member of the Department Board and also a member of the nomination committee.

Renganathan, Venkatraman
Venkatraman is a postdoctoral fellow at the department of automatic control at Lund University. He holds a PhD from the University of Texas, Dallas, USA.

He is actively working on regret analysis for learning based controllers such as minimax adaptive control and other robust control algorithms.

During 2023 he attended and presented his papers at CDC Singapore and ACC San Diego. He attended the CyDiSy Workshop held at Monte-Verita in Switzerland. He gave talks at TU Darmstadt, TU Berlin and University of Stuttgart as a part of his DAAD Postdoc fellowship that he received for his research on Artificial Intelligence for Cyber-physical Systems. He also designed a learning based model predictive controller for the safe landing of re-entry space vehicle being a part of the European Space Agency project spearheaded by DEIMOS research consortium.

He is currently exploring the topic of probabilisitic robust control where he is extending nu-Gap metric for systems with probabilistic uncertainties

Salt Ducaju, Julian
MSc in Aeronautical Engineering from Universidad Politecnica de Valencia (2018) and he did his master's thesis in the University of California, Berkeley with Professor Masayoshi Tomizuka as a visiting student researcher. Since February 2019 a PhD student at the department where he is an affiliated WASP-AS student.

The main focus of his research work has been in the fields of autonomous vehicles and robotics**.**

Julian presented his licentiate thesis *Human-Robot Collaboration for Kinesthetic Teaching,* in January 2023.

Sinnema, Yde
MSc in Electrical Engineering, Vrije Universiteit Brussel and Université Libre de Bruxelles, Belgium in 2023. He joined the department as a PhD student in September of this year.

He is supervised by Martina Maggio and will be doing research on timing discrepancies in control systems.

His teaching activity consisted of lab supervision in the *Basic Control* course

Soltesz, Kristian
PhD in Automatic Control at Lund University in 2013, based on research conducted at University of British Columbia. Since 2019 Kristian is Reader (Docent) in Automatic Control, with research focus on medical models and control systems.

His research interest focus on cyber-physical systems in medicine and industrial applications. Current research projects involve evaluation of donor hearts using feedback technology, data-driven methods for sustainable minig of minerals, and novel methodologies for individualized pharmacological modeling.

He is the main supervisor of PhD students Ylva Wahlquist and Harry Pigot and Frida Norlund, co-supervisor for PhD student Martin Gemborn-Nilsson, and mentor for postdoc Jesper Sundell. He is also involved in the work of PhD student Emil Sundström.

Kristian serves as director of the Engineering Physics program in Lund (35 %), and is teaching a course in *physiological modeling*.

Stenberg Oskar
Amanuens (Research engineer assistant) since 2022. He has been at the departement in various part-time roles since 2016, and is currently studying year 4 on a Master of Science in Computer Science.

Oskar is currently getting familiar with the digital infrastructure at the departement and is responsible for setting up a testing environment that partly aims to test our procedures for deploying from backups as well as serve as a test-bed for changes to our digital environment before they are rolled out. He also helped guiding summer workers to completing their tasks.

Sundell, Jesper
He joined the department as a postdoc in April 2022 to work in the project entitled Learning pharmacometric model structures from data.

Jesper holds a PhD in quantitative pharmacology with a focus on model-based drug development, which he obtained in 2021 at Gothenburg University.

Research interests include pharmacometrics, precision medicine and machine learning.

He also works as an advisor in a project related to the antitubercular drug rifampicin. The project involves a clinical study which is conducted in Västra Götalandsregionen.

Sundström, Emil
MSc in Engineering Physics program, 2022. He has worked at Combine Control Systems until November 2023, when he started as PhD at the department.

His research will mainly be about offloading computations to the cloud for enhanced device control.

Tegling, Emma
PhD in Electrical Engineering from KTH Royal Institute of Technology, Sweden, 2019 and MSc Engineering Physics, 2013 from the same institute. 2019-2020 she was a postdoc at Massachussetts Institute of Technology (MIT). Emma is Senior Lecturer (associate professor) since 2021 and Deputy Head of Department starting 2024.

Emma Tegling's research revolves around analysis and control of network systems. Together with her research group, she is interested in fundamental questions regarding scalability, robustness and controllability of systems defined over networks, and in applications including energy systems and social networks.

Emma is one of the leaders of the WASP NEST (Novelty, Excellence, Synergies and Teams) project on Learning in Networks, which is a collaboration with KTH and Uppsala university.

She is supervising PhD students and MSc students, and teaches the basic course in Automatic Control as well as Projects in Systems, Control and Learning.

Tufvesson, Pex
MSc in Electrical Engineering in 1997 from LTH. Since then he has been working as a chip designer on GPUs, supercomputing, communication systems, encryption and even synthesizers.

He has founded startups and is the brain behind ventures in wearables and child healtcare systems. Employed by Ericsson Research, and in 2021 he started as an industrial PhD student at the Department of Automatic Control.

He is part of the research group working with EEG-based Brain-Computer Interfaces led by Professor Bo Bernhardsson. His research is all

about real time online classification and signal analysis.- basically decoding the future, one brain wave at a time.

Upadhyaya, Manu
MSc in Engineering Physics, 2020, Lund University; MSc in finance, 2020, Lund University. He is a PhD student since July 2020.

His research interests are in continuous optimization and its applications, e.g., machine learning, control, and finance. Currently, his focus is on the design and performance analysis of first-order algorithms for convex optimization problems.

Teaching assignments in the following courses; *Modeling and learning from data*, *Optimization for learning* and *WASP: deep learning*.

Vladu, Emil
MSc in Engineering Physics from Lund University, 2018. PhD student at the department since August 2019.

His supervisor is Anders Rantzer and his research project mainly concerns control in large-scale dynamic networks.

During the spring of 2023, he was a TA for the course *Control Theory*. During the autumn of 2023, he was a TA for the course *Nonlinear Control and Servo Systems*, in which he was also responsible for a laboratory exercise as well as compiling the exam.

Voitenko, Volodymyr
PhD in Technical Sciences, Institute of Electrodynamics at the National Academy of Science, Ukraine. Radio-engineer (MSc, honors), Leningrad Electrical Engineering Institute, USSR. PhD in Technical Sciences, Docent, Associated Professor on the Department of Electronics, Automation, Robotics and Mechatronics at the Chernihiv Polytechnic National University (Ukraine).

Research in the project *Increasing the speed of analysis of images obtained from unmanned aerial vehicle*.

Teaching assignments during fall 2023 at the Chernihiv Polytechnic National University (Chernihiv, Ukraine) of the following courses: *Display systems* (MSc in Electronics) and *Introduction to Electronic Systems* (BSc in Electronics). Supervising PhD student Maksym Solodchuk (Chernihiv Polytechnic National University, Ukraine).

Wahlquist, Ylva
MSc (2019) and PhD student at the Department since May 2020.

Her research interests include pharmacometric modelling and control of hemodynamic parameters for intensive care and heart transplantation in collaboration with the research company Igelösa Life Science. She works together with Henry Pigot, Jesper Sundell and Kristian Soltesz.

During 2023, Ylva received a travel grant from the County Governor Nils Hörjel Research Fund at LTH for a planned visit in Prof. Antonio Visioli's group at the University of Brescia, Italy, in 2024.

During the year, Ylva has been a teaching assistant for the *Physiological Models and Computation course* and the *Process Control & Systems Engineering course*. During the spring, Ylva supervised a master thesis with Amanda Gustafsson named *Towards individualised anaesthesia: A comparison between target-controlled infusion and closed-loop control*.

Westin, Eva
PhD in French linguistics in 2003 and was a lecturer at the Center for Languages and Literature until 2007. Administrator at the Department of Automatic Control since November 2008 and administrative manager since December 2017.

Eva has the overall responsibility for the administration at the department and special responsibility for human resources, guests and conferences.

She also handles part of the administration for the research study program. She is part of the workplace health and safety team at the department.

She has been a board member of the Equality group at the Faculty of Engineering and still

actively works with these questions at the Department of Automatic Control. She is current member of the board for AI Lund and of the Faculty Board at LTH. Coordinator, since 2022, for the ELLIIT Focus Program.

Wisbrant, Jonas
Jonas has an academic educational background in political science, software development and strategic communication.

Within the framework of the AI Lund network and Lund University's profile area for natural and artificial cognition, Jonas Wisbrant runs strategic and operational communication, networking and public education.

Wu, Dongjun
Dongjun joined the department as a postdoc in May 2022. He got a double PhD degree from Université Paris-Saclay CNRS-L2S (Automatique) and Harbin Institute of Technology (Control science and engineering), March 2022.

His current research interests include large scale systems, optimal transport and geometric methods of nonlinear systems. He is working in the project Scalable Control of Interconnected Systems funded by ERC.

In the fall of 2023, he taught a PhD course (6 out of 10 lectures) *Optimal Control* with Prof. Björn Olofsson and Prof. Karl Johan Åström.

He is currently co-supervising a PhD student Emil Vladu, who is mainly working on scalable control of large scale systems.

Ziemann, Ingvar
MSc in Mathematics (2018, joint with KTH), Stockholm University. MSc in Economics (2017), Stockholm School of Economics and PhD in Decision and Control (2022), KTH. At present he holds a postdoc position at UPenn. Funded by VR grant managed by Lund.

His research interests are Machine Learning, Controls, Probability Theory, Statistics.

JÄLM@REGLER - THE GENDER EQUALITY, EQUAL OPPORTUNITIES, AND DIVERSITY GROUP AT THE DEPARTMENT

Richard Frida Johan Yiannis Henry

Jälm@regler, the gender equality, equal opportunities, and diversity group at our department. It's commendable that this group has been actively working since 2014, organizing seminars and workshops with invited speakers to address a wide range of topics, from research to ergonomics, security, and implementation. Creating a space for discussing gender equality and diversity during coffee breaks is indeed crucial for fostering awareness and driving positive change.

During 2023, we have had a number of different activities in the group which consists of the following members of Richard Pates, Frida Norlund, Johan Lindberg, Yiannis Karayiannidis and Henry Pigot.

The project "Historical Female Influencers in Automatic Control" is particularly inspiring. By highlighting female pioneers and role models in the field of control technology, we are not only celebrating their contributions but also providing valuable inspiration for today's students. These female pioneers and role models are shaping the narrative and paving the way for future generations in the field of automatic control. Their stories serve as powerful reminders of the impact women have had

Margret Bauer and Eva Westin - both contributing to the project Historical Female Pioneers.

and continue to have in technology and academia. Other contributors to this project are Charlotta Johnson, Professor; Kristian Soltesz, Associate Professor; Tore Hägglund, Professor Emeritus; Ulrika Belyazid, Science Journalist and Eva Westin, Administrative Manager.

Lise Meitner: As a professor from HAW Hamburg, Margret Bauer has taken on the role of Lise Meitner Professor. Her expertise and dedication contribute significantly to various aspects of the department's work, including supervision, teaching, JäLM activities, and discussions related to the work environment.

Lastly in December, the department invited LTH´s dean Annika Olsson to discuss LTH's visions and strategies demonstrates a commitment to transparency and alignment within the faculty. It's essential to ensure that everyone is aware of the overarching goals and aspirations.

Shows disstribution of males and females at the Department as well as divided per category

AWARDS

GRANTS

Travel grant from the County Governor Nils Hörjel Research Fund
Ylva Wahlquist received a travel grant from the County Governor Nils Hörjel Research Fund at LTH for a planned visit in Prof. Antonio Visioli's group at the University of Brescia, Italy, in 2024.

Travel grant from the Royal Physiographic Society
Albin Heimerson received a travel grant from the royal physiographic society in Lund to present a paper at IFAC WC 2023 in Yokohama.

Travel grant from the Royal Physiographic Society
Felix Agner received a travel grant from the royal physiographic society in Lund to travel to Aalborg and conduct experiments in their Smart Water Infrastructure lab.

Best paper runner-up award
The paper *Real-Time Anomaly Detection Using Distributed Tracing in Microservice Cloud Applications* by Mahsa Raeiszadeh, Amin Ebrahimzadeh, Ahsan Saleem and Roch Glitho (Concordia University, Canada); Johan Eker (Lund University/Ericsson, Sweden); Raquel Mini (Ericsson, Sweden), was selected for the best paper runner-up award at IEEE CloudNet 2023.

LMK Residence scholarship
Kristian Soltesz received a scholarship from the LMK foundation which enabled to spend one week at Björkliden together with his group, focusing on long-term research goals with a stunning arctic back-drop.

Department of the year 2023
The Department of Automatic Control received a diploma, flowers, and chocolate for the *Department of the Year 2023,* from the Mechanical Engineering student guild. The citation reads "*Organiserad institution som ger mycket hjälp i kurser och har positiv kultur. Många plus på hur mycket hjälp de ger i ex-jobbsletande och stöd i det!*" (translate into: A well organized depart-ment that gives support in courses and has a positive environment. A plus for the support in finding Master's Thesis topics).
- Thanks for all your efforts with the teaching this year, and let us continue to foster the positive and helpful culture in our teach-ing, says Björn Olofsson, director of undergraduate studies.

ASSIGNMENTS

BOARD MEMBER

Årzén, Karl-Erik
Chair of the Research Management Group for the Wallenberg Autonomous Systems and Software Program (WASP).
Member of the WASP Executive Committee.
Member of Research Board for the Faculty of Engineering, Lund University.
Member of the Scientific Advisory Board of SMaRC, Swedish Maritime Robotics Center.

Eker, Johan
Chairman of the Advisory Board for "Internet of Things and People" Research Center at Malmö University.

Johnsson, Charlotta
Board member of EFL (Executive Foundation Lund), Lund, Sweden.
Board member of Innovation Skåne AB, Sweden.
Board member of IUC Syd (Industriellt utvecklingscentrum Syd), Malmö, Sweden.
Other Board assignments in national and international companies.

Rantzer, Anders
Member of the Steering Committee for the International Symposium on Mathematical Theory of Networks and Systems.
Member of Editorial Board for the journal Annual Reviews in Control.
Member of WASP research management group for Mathematics in AI.
One of two Co-directors for the ELLIIT focus period program
Chairman for the Royal Physiographic Society of Lund

Tegling, Emma
Secretary of the European Control Association (EUCA)

Westin, Eva
Member of the Board for AI Lund.
Member of the Board at the Faculty of Engineering since 2022.

Wisbrant, Jonas
Member of the Board for AI Lund.
Member of the steering group for NAC (Natural and Artifical Cognition)

MEMBER OF INTERNATIONAL PROGRAM COMMITTEE (IPC) AND ORGANIZING COMMITTEES

Bernhardsson, Bo
Member of the Organizing Committee for the WASP-DDLS (Data-driven Life Science) synergy project.

Eker, Johan
Part of the Program Committee for RTAS 2024

Johnsson, Charlotta
Member in the European Control Conference Committee 2024, focus on Industry Day.

Rantzer, Anders
General Co-chair for the organization of European Control Conferenence 2024 in Stockholm.

Tegling, Emma
Publicity Chair for the organization of European Control Conferenence 2024 in Stockholm.
Social Media Chair for 2023 IEEE Conf. of Decision and Control in Singapore, member of OC
Member of IPC for International Symposium on Mathematical Theory of Networks and Systems (MTNS)

OPPONENT AND MEMBER OF EXAMINATION COMMITTEE

Årzén, Karl-Erik
Member of the PhD examination committee of Ruslan Seifullaev, Uppsala University, June 2.

Giselsson, Pontus
Opponent for Damianos Tranos, PhD thesis, KTH, Stockholm, October 23.
Member of examination committee for Daniel Arnström, PhD thesis, Linköping University, June 9.
Member of examination committee for José Iglesias, PhD thesis, Chalmers, Göteborg, June 7.
Member of examination committee for Yuchao Li, PhD thesis, KTH, Stockholm, March 21.
Member of examination committee for Michael Sedlmayer, PhD thesis, University of Vienna, February 24.

Johnsson, Charlotta
Member of the examination committee for PhD-candidate Simon Tallvod, title *Tools for digital twins in continuous downstream processing*, November 24.

Karayiannidis, Yiannis
Part of the examination committee for Marios Kiatos (AUTH, Greece) in February.
Part of the examination committee for Antonios Sidiropoulos (AUTH, Greece) in August.

Maggio, Martina
Member of the examination committee of Filippo Muzzini, University of Modena.
Docent evaluator for Pontus Ekberg, Uppsala University.

Olofsson, Björn
Pre-examiner of the Ph.D. Thesis by Anam Tahir on May 21. Faculty of Technology, University of Turku, Finland. Thesis title: *Formation Control of Swarms of Un- manned Aerial Vehicles*.
Opponent/reviewer at the Licentiate Thesis seminar by Xiao Chen on May 16. Division of Decision and Control Systems, KTH Royal Institute of Technology, Sweden. Thesis title: *Safe Intersection and Merging Coordination of Connected and Automated Vehicles*

Opponent/reviewer at the Licentiate Thesis seminar by Krister Blanch on September 15. Department of Mechanics and Maritime Sciences, Chalmers University of Technology, Sweden. Thesis title: *Beyond-application datasets and automated fair benchmarking*.

Rantzer, Anders
Member of examination committe for PhD defense by Erik Gärtner, Lund, January 13.

Tegling, Emma
Member of examination committe at PhD defense of Damianos Tranos, KTH
Licentiate thesis opponent for Anh Tung Nguyen, Uppsala University

ADVISORY COMMITTEES AND WORKING GROUPS

Årzén, Karl-Erik
Elected member of the Royal Swedish Academy of Engineering Sciences (IVA).

Como, Giacomo
Chair of the IEEE-CSS Technical Committee on Networks and Communications.
co-Organizer of the ELLITT Focus Period and Symposium "Network Dynamics and Control", Linköping on September 4 – October 6, 2023

Eker, Johan
Co-organized the Real-time Cloud workshop in Vienna as part of ECRTS 2023.

Johnsson, Charlotta
Chair of ISO TC184/SC5 (Industrial Automation / Interoperability, integration and architectures for enterprise systems and automation applications).
Member in ISO SMCC (Smart Manufacturing Coordination Committee), reporting directly to ISO Technical Management Board.
Voting member in the standardization committee ISA95 and ISA88.
Board member for Diploma Engineering at University of Limerick, Ireland.
Member in SIS and SEK. She serves as the Swedish expert in the international IEC 62264, IEC 61512, ISO 22400 and ISO 15746 standards, as well as in the groups IEC AhG3, IEC TC65E AhG1, as well as in the joint committee IEC/TC65-ISO TC184 JWG21.
Member of several boards and working groups at Lund University.
Part of ECC 2024 industry committee (European Control Conference 2024).
Part of IFAC Activity Fund committee (international Federation of Automatic Control).
Part of IEEE Control System Society Industry Committee (IEEE CSS).

Maggio, Martina
Member of the International Program Committee for Foundations of Software Engineering (FSE 2023)
External Reviewer for the International Program Committee Euromicro Conference on Real-Time Systems (ECRTS 2023).

Rantzer, Anders
Member of review panel for completed projects funded by the European Research Council.

Member Evaluation Committee for Wallenberg Academy Fellows.
Principal Investigator in the project "*AI for Guidance Navigation and Control*" funded by the European Space Agency.
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.

Tegling, Emma
Co-organizer for the ELLIIT Focus Period on Dynamics and Control of Complex Network Systems in Linköping 2023
Chair of Chapter Activities, IEEE Control Systems Society (2022-2023)

Voitenko, Volodymyr
Part of organizing and holding of the scientific and technical conference MODS-2023, November 13-15.
Part of organizing and holding of the III International Scientific and Practical Conference *Novel Technologies of Smart Society*, NTSS-2023, December 19.

OTHER ASSIGNMENTS

Årzén, Karl-Erik
Associate Editor for Real-Time Systems Journal.
Associate Editor for the Leibnitz Transactions on Embedded Systems (LITES).
Associate Editor for ACM Transactions of Cyber-Physical Systems.

Como, Giacomo
Associate Editor of Automatica.
Senior Editor of the IEEE Transactions on Control of Network Systems.

Edelborg, Cecilia
Part of the Group for Gender and Equality issues (JäLM) at the Faculty of Engineering.

Johnsson, Charlotta
Serving as the IFAC Liaison with IEC 65A.
Serving as a member in IEEE CSS industry Committee.

Karayiannidis, Yiannis
Associate Editor for IEEE Robotics and Automation Letters since 2018.
Associate Editor for IEEE RSJ International Conference on Intelligent Robots and Systems (IROS) since IROS20.
Associate Editor for European Control Conference (ECC) since ECC19.
Associate Editor for IEEE International Conference on Robotics and Automation (ICRA) since ICRA22.

Maggio, Martina
Member of hiring committee and evaluator for: TU Dortmund, TU Hannover, Scuola Superiore Sant'Anna.

Rantzer, Anders
Director of the ELLIIT Focus Program.

Soltesz, Kristian
Director of the Engineering Physics program at Lund University.
CEO of AB Benoso (engineering consultancy) and GinkGo bikes (locally manufactured environment friendly transportation solutions).
Panel member as Expert Reviewer. European Science Foundation.
Member of the Steering Group of the Engineering Health, LTH profile area.

Westin, Eva
Coordinator of the ELLIIT Focus Program since 2022.

Voitenko, Volodymyr
Teaching assignment at Chernihiv Polytechnic National University, Department of Electronics, Automation, Robotics and Mechatronics (Ukraine), from September through December 2023.

LONGER VISITS ABROAD

Maggio, Martina
In April 2020, Martina Maggio started a double appointment as full professor at the Department of Computer Science of Saarland University, Germany. During 2023 she had only 20% duty at the Department of Automatic Control, Lund University.

LECTURES BY OUR PERSONNEL OUTSIDE THE DEPARTMENT

Agner, Felix
Hydraulic Parameter Estimation in District Heating Networks, IFAC - Yokohama Japan July 12. Conference presentation in invited session.
Numerical Estimation of Improved Heat Transport Capacity using Load Control in a District Heating Grid, Smart Energy Conference - Copenhagen Denmark, September 12. Conference presentation.
Hydraulic Parameters in District Heating Systems - Estimating Them From Data and Leveraging Them For Fair Heat Distribution, Aalborg Denmark October 9. Invited Seminar Presentation.

Como, Giacomo
On a centrality maximization network formation game, GERAD Informal Systems Seminar, (Montreal, Canada), October 13. Invited talk.
On a centrality maximization network formation game, 22nd annual SAET Conference, (Paris, France), July 20. Invited talk.
Targeting interventions for network volatility reduction, IFAC Workshop *Emerging Trends in Resilient Control of Networked Systems*, (Yokohama,Japan), July 9. Invited talk.
On a centrality maximization network formation game, Institute for Mathematical Sciences, National University of Singapore (Singapore), April 5. Invited talk.

Giselsson, Pontus

Computational mathematics for data science, Technical University of Denmark, Copenhagen, Denmark, November 15–17. Invited talk.

Session: *Optimization in Inverse Scattering: from Acoustics to X-rays,* Applied Inverse Problems, Göttingen, Germany, September 2-8. Invited talk.

Session: *First-order optimization methods,* EUROPT 2023, Budapest, Hungary, August 23-35. Invited talk.

PEP Talks, Université catholique de Lovain, Lovain-la-Neuve, Belgium, February 13-14. Invited talk.

Johnsson, Charlotta

Sonja Kovalevsky och kvinnliga pionjärer inom reglerteknik, Sonja Kovalevsky dagarna, Örebro, Nov 10.

Klimatvetenskapens rön om hur samhället behöver ställa om, deltagande i seminariet Bekämpa klimatutmaningarna med standardisering och vetenskap, möte mellan Standardisering och Akademi, Oct 17.

Historical Female Influencers in Automatic Control, presentation at Board of Gender Equality, together with Eva Westin, at LTH, Dec 6.

Rantzer, Anders

Towards Optimal and Adaptive Control for Large-scale Systems, Invited virtual seminar at Technion, Israel, May 22.

Towards Robust and Adaptive Control for Large-scale Systems}, 11th Harry Nicholson Distinguished Lecture in Control and Systems Engineering at University of Sheffield, June 20.

On Large-scale Systems and Adaptive Control}, Invited presentation at 29th Nordic Congress of Mathematicians, Ålborg, July 4.

Dual Control Revisited, Plenary lecture at 62nd IEEE Conference on Decision and Control, Singapore, December 14.

Tegling, Emma

Scalability of distributed control: fragilities and performance limitations, Invited virtual seminar at Technion, Israel, April 24.

Voitenko, Volodymyr

Organised joint lectures for Ukrainian students:

Autonomous Flight, October 17. Together with Lara Laban, UAS@LU. Part of the course *Introduction to Electronic Systems.*

On a winding road with adaptive control, October 17. Together with Björn Wittenmark. Part of the course *Introduction to Electronic Systems.*

Automatic control - training course, November 24. Together with Alexander Pisarevskiy. Part of the master's course *Display Systems*.