Activity Report 2024

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Activity Report 2024

AUTOMATIC CONTROL | LUND UNIVERSITY

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UNIVERSITY

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Activity Report 2024

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Content

Introduction 7

AUTOMATIC CONTROL HIGHLIGHTS OF 2024 9

Education 11

UNDERGRADUATE STUDIES 12
GRADUATE STUDIES 14
DOCTORAL DISSERTATIONS 16
LICENTIATE DISSERTATION 19

Research 21

EXCELLENCE CENTERS AND NATIONAL PROJECTS 22
PROFILE AREAS' WORK CONTINUES 26
RESEARCH AREAS 27
LARGE SCALE SYSTEMS AND LEARNING 28
AUTONOMOUS REAL-TIME SYSTEMS 39
INNOVATIVE CONTROL APPLICATIONS 41

Publications and seminars 57

PUBLICATIONS 2024 58
SEMINARS AT THE DEPARTMENT 67

External Engagement 71

Economy 77

ECONOMY 78
FUNDING 79

Staff 81

LONG-TERM VISITORS 88
BOARD OF THE DEPARTMENT 88
ACTIVITIES OF STAFF 88
AWARDS 100
ASSIGNMENTS 101
LECTURES BY OUR STAFF OUTSIDE THE DEPARTMENT 106
POPULAR SCIENCE 107

Introduction

A summary of the activities at the Department of Automatic Control, Lund University during the period January 1 to December 31, 2024

AUTOMATIC CONTROL HIGHLIGHTS OF 2024

2024 was a year of growth and achievement for our department. We welcomed two new PhD students and a research engineer, bringing our team to 59 members. Our educational program offering in total 18 different undergraduate courses, show an increase in popularity. This year 1,457 students passed, and 66 students presented their Master's Theses at our department. Additionally, we offered two PhD courses, and celebrated the defense of three PhD Theses, bringing our total number of PhD graduates to 145. We also celebrated the defense of one Licentiate Thesis.

Our involvement in the WASP research program grew, with 19 funded PhDs and postdocs, including four industrial PhD students and two postdocs. Five of our other PhD students are WASP affiliated and are also participating in the courses offered within the WASP Graduate School. This year, some of our PhD students participated in international study trips, with destinations including Canada, USA, Italy, and Germany, providing possibilities for networking and new research collaborations.

The euRobotics week, a well-established event, took place over three days in late November, with participation from Department of Computer Science and Cognitive Robotics Lab under the AI Lund umbrella. Our research visibility was also clear through various profile areas within both Lund University and the Faculty of Engineering.

We highlighted the project "Historical Female Influencers in Automatic Control" at several international events and conferences, adding new portraits to our collection on Historical Female Influencers.

Financially, we maintained economic stability with a net result of 0.6 MSEK and a turnover of 72.8 MSEK.

Notable events included the ELLIIT Focus period on Security and Fault Tolerance of Cyber-Physical Systems, organized by Martina Maggio and Mikael Asplund, and the EUROPT 2024 conference, organized by Pontus Giselsson and a team of PhD students, supported by student amanuenses. The European Control Conference (ECC) was held in June in Stockholm, concluded with a celebration of 75 years of Automatic Control in Sweden. Next year we are looking forward to organizing both the Swedish Control Conference and another ELLIIT Focus period, this time on robot learning, both taking place in Lund.

In 2024, Margret Bauer concluded her tenure as a Lise Meitner Professor, and Anders Blomdell received an award from the Royal Physiographic Society for his significant contributions as a Research Engineer at LTH.

The field of Automatic Control remains central to the rapidly developing areas of AI, Machine Learning, and their applications. We are committed to continuing our innovative research and exploring new solutions within our field of research, as well as continuing offering high-quality courses at both undergraduate and graduate level within our field.

Björn Olofsson and Monika Rasmusson

Education

Education at undergraduate and graduate level including dissertations 2024

UNDERGRADUATE STUDIES

The engineering education at LTH, the engineering faculty of Lund Univeristy, follows the central European 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), Information and Communication Engineering (C), Environmental Engineering (W), Engineering Mathematics (Pi), Industrial Management and Engineering (I), Biotechnology (B), Engineering Nanoscience (N), Chemical Engineering (K), and Biomedical Engineering (BME). Our advanced courses are included in more than fifteen of the master-level specializations in the various programs.

During 2024, there were 1 502 course registrations and 1 457 passed grades were awarded, which corresponds to 199 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 have become so popular that we, unfortunately, had to restrict the number of students. This is a result of lack of staff resources, limited availability of lab processes and computational infrastructure. 66 students completed their Master's Thesis projects, and a total of 43 theses were presented. A list of the Master's Theses is given in the *Publications and Seminars* chapter.

The two-year international master program-*Machine Learning Systems and Control* was started in 2020. The program is managed by Mikael Nilsson at the Mathematics Department and Bo Bernhardsson. In 2024 a fifth batch of 29 students was admitted, which is an increase in comparison to previous year.

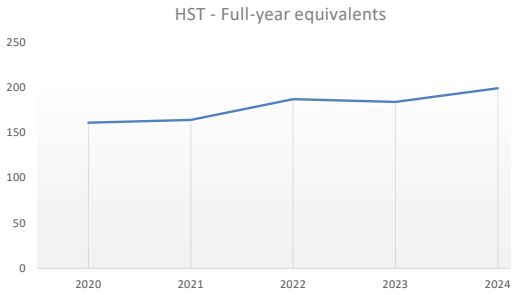
Most of our lectures have now been recorded and we have also developed new formats of teaching, which we will maintain also in the future, when we have returned to a more normal post-pandemic situation.

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

The department is looking forward to the next teaching year 2025, where we will start a new course on *Cloud Computing* and continue the revision of our courses on *Process Control* for the students in the Environmental, Chemical, and Biochemical Engineering programs.

CHATGPT IN EXAMINATION

Following up on the topic of exams, in August 2024, Felix, Harry and Julia, PhD students at the department, conducted an experiment. In this experiment a test group consisting of students, without prior knowledge of a basic course in automatic control, with the help of a large language model were asked to conduct a live exam in the course. The exams were then marked in parallel with the examinees' exams. Preliminary results show that several of the experimental group's exams passed, but without superior grades. The students who conducted the experiment expressed frustration at not understanding the meaning of the solutions they submitted.



Development over the last five years of full-year equivalents

TOTAL NUMBER OF STUDENTS WHO PASSED OUR COURSES 2024

Automatic Control, Basic Course
(FRTF05 Reglerteknik) 741
Physiological Models and Computations
(FRTF01 Fysiologiska modeller och beräkningar) 35
Systems Engineering
(FRTF10 Systemteknik) 70
Control Theory
(FRTF15 Reglerteori) 9
Introduction to Machine Learning, Systems and Control
(FRTF25 Introduktion till maskininlärning, system och reglering) 29
Real-Time Systems
(FRTN01 Realtidssystem) 38
Nonlinear Control and Servo Systems
(FRTN05 Olinjär reglering och servosystem) 33
Automatic Process Control
(FRTN25 Processreglering) 19
Network Dynamics
(FRTN30 Nätverksdynamik) 50
Mathematical Modeling, Advanced Course
(FRTN45 Matematisk modellering, fortsättningskurs) 39
Optimization for Learning
(FRTN50 Optimering för maskininlärning) 45
Automatic Control, Advanced course
(FRTN55 Reglerteknik, fortsättningskurs) 37
Real-Time Systems
(FRTN60 Realtidssystem) 5
Modeling and Learning from Data
(FRTN65 Modellering och inlärning från data) 75
Project in Systems, Control and Machine Learning
(FRTN70 Projekt i system, reglering och maskininlärning) 47
Learning-Based Control
(FRTN75 Inlärningsbaserad reglering) 52
Applied Robotics for Architectures
(FRTN80 Tillämpad robotik för arkitekter) 20
Applied Robotics
(FRTN85 Tillämpad robotik) 46
Degree Project in Automatic Control
(FRTM01/FRTM05 Examensarbete i reglerteknik) 66
Bachelor Project in Automatic Control
(FRTL01 Kandidatarbete i reglerteknik) 1

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 2024 three Doctoral Theses were defended by Henry Pigot, Julian Salt Ducaju and Olle Kjellqvist. One Licentiate Thesis was presented by David Ohlin. During the year we have admitted Sebastiano Fregnan and Ask Hällström as new PhD students.

The following PhD courses were given at the department in 2024:

- *Control System Synthesis*; Bo Bernhardsson, Olle Kjellqvist, Karl Johan Åström.
- *Game theory*; Giacomo Como.

Björn Olofsson and Lars Nielsen (Linköping University) held a PhD course *Optimal Vehicle Maneuvers* at Chalmers University January-April, 2024.

Charlotta Johnsson was involved as a guest speaker in the following courses in 2024:

- Master course *Automation in Complex Systems*, April 26.
- Master course *Innovation Engineering*, September 3.
- PhD course *Innovation and Value Creation in Research*, October 17.

There are also several PhD courses organized within the WASP Graduate School program, 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
	Mathematics for Machine Learning
	Software Engineering and Cloud Computing
Elective courses	*Deep Learning for Natural Language Processing*
	Deep Learning
	Graphical Models, Bayesian Learning and Statistical Relational Learning
	High-dimentional statistics and optimization
	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)	*Introduction to Mathematics for Machine Learning*

WASP Study Trip to Italy

On September 22-28, the WASP GSM study trip to Italy took place, organized by WASP Faculty members Karl-Erik Årzén and Martina Maggio, along with industrial postdoc Dimitris Paraschakis. A group of 35 PhD students, primarily from their first and second years, participated. The trip aimed to strengthen both the students' international network and their relationships with one another. The trip began on Sunday, September 22, with a day dedicated to social and cultural exploration. Most students visited Florence, and in the evening, a WASP celebration dinner was held in Pisa.

The following day, the group spent time in Pisa, starting with a visit to Antonio Bicchi's robotics lab at the University of Pisa in the morning, followed by an afternoon visit to Giorgio Buttazzo's systems group at Scuola Superiore Sant'Anna.

On Tuesday, the group traveled to Modena, where they visited Marko Bertogna's group at the University of Modena and the HiPeRT spin-off company, which specializes in autonomous vehicles and has participated in events like the Indy Autonomous Challenge and the Abu Dhabi Autonomous Racing League.

Wednesday's activities began with a visit to Tetra Pak in Modena, providing insights into modern manufacturing and automation. The afternoon was reserved for a social event at the Ferrari Museum in Maranello, showcasing Ferrari's iconic racing and sports cars. That evening, the group traveled to Milan.

Thursday was spent at the Politecnico di Milano (*Polimi*), where the students met with Alberto Leva and Maria Prandini. The students presented brief research pitches and were given a tour of the robotics and autonomous vehicle labs by Andrea Maria Zanchettin and Matteo Corno.

The final day, Friday, September 26, began in Turin with a visit to Reply, Italy's largest AI-focused consulting company. The group was treated to various demos, including robot dogs, XR, and warehouse automation technologies. After lunch, they attended the closing day of Italy Tech Week, an industry fair with a strong AI focus. According to anonymous evaluations, the study trip was highly appreciated by the students.

Pisa

Polimi

DOCTORAL DISSERTATIONS

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


Henry Pigot


Julian Salt Ducaju


Olle Kjellqvist

AFTERLOAD SYSTEM DESIGN FOR FUNCTIONAL DONOR HEART ASSESSMENT

Pigot, Henry

ISBN 978-91-8039-920-3

Heart transplantation is a life-saving procedure for patients with end-stage heart failure. However, conservative acceptance criteria result in most donated hearts being discarded. Enabling clinicians to assess heart function after organ procurement can pave the way for the safe use of hearts that are currently rejected. This thesis focuses on improving techniques for the direct, controlled assessment of a recovered heart's hemodynamic performance. The first paper reviews ex situ working heart models and cardiac afterload devices, discussing challenges in emulating cardiac afterload and detailing an experimental method for a working porcine heart model. Paper II analyzes Windkessel models, which are the standard cardiac afterload model. It assesses their applicability and limitations, and presents a method for identifying model parameters from sampled data. The analysis concludes that complex models like the 4-element Windkessel model are not identifiable from relevant experimental data. The third paper reformulates traditional Windkessel models for a more accurate representation of hemodynamic responses. Using power as model input, the paper offers a more physiological representation of the hemodynamic response to various afterloads, aiding in afterload device design. In Paper IV, the efficacy of a pneumatic afterload device creating a range of physiological loading conditions is investigated in six porcine hearts. The experiments show the concept's utility in testing hearts under multiple conditions. Paper V introduces an actively controlled variable flow resistance, demonstrating its ability to reproduce a wide range of afterload dynamics while enforcing safe pressure limits for heart assessment. The afterload concept, outlined in Paper I, is investigated in silico using the methods from Paper III. A physical prototype and pilot experiments led to a patent submission for the design. These papers advance functional heart assessment by both

refining Windkessel-model-based simulation tools (Papers II and III) and exploring novel afterload device concepts (Papers I, IV, and V). Together, they constitute a step towards clinical implementation of technology that can safely enable more transplantations by providing an improved basis for decision-making.

CONTROL STRATEGIES FOR PHYSICAL HUMAN—ROBOT COLLABORATION

Salt Ducaju, Julian

ISBN 978-91-8104-023-4

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, to increase flexibility in manufacturing applications. As a consequence, industrial environments would lose their fixed structure, thus increasing the uncertainties present in this workspace shared between humans and robots. This thesis presents robot control methods to mitigate such uncertainties and to improve the involvement of human operators in industrial settings where robots are present, with a particular focus on manual robot guidance, or kinesthetic teaching.

First, the accuracy of manual robot guidance was increased by reducing the joint static friction without altering the robotic task execution, using additional degrees of freedom (DOFs) available in collaborative robots. Additionally, previous methods for a fast identification of the source of robot—environment physical contact in partially-unknown industrial environments were evaluated, extended, and modified to perform effective manual corrections of the robot motion. Then, an iterative learning method was proposed to achieve a more accurate use of manually-defined trajectories, while allowing a safe physical robot—environment interaction.

Moreover, safety is a major concern in uncertain scenarios where humans and robots collaborate. Regulating the robot—environment interaction forces, e.g., using impedance control, would improve safety, yet undesired parts of the collaborative workspace might need to be entirely avoided. To this purpose, a stable online variation of robot impedance during the manual guidance of the robot was proposed. This proposal was later extended to further improve safety by considering a prediction of human guidance with coordinated robot control. Furthermore, the additional DOFs in collaborative robots were used to develop a stable online impedance variation method for robot obstacle avoidance without requiring modification of the main robot task.

All methods presented were tested experimentally on a real collaborative robot.

MINIMAX ADAPTIVE CONTROL AND ESTIMATION

Kjellqvist, Olle

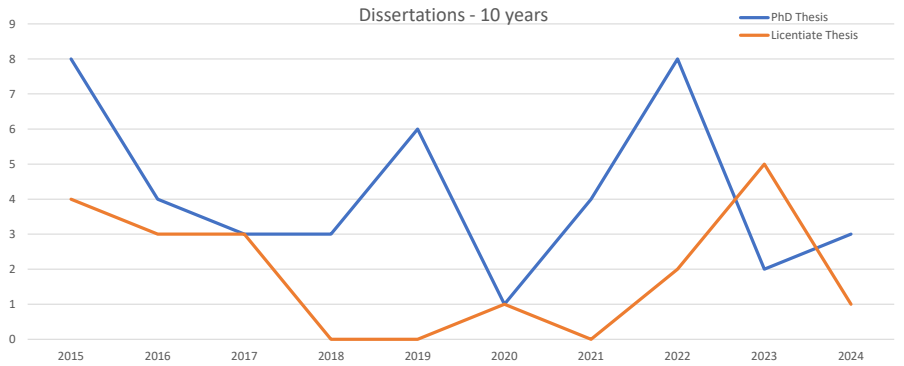
ISBN 978-91-8104-168-2

This thesis presents five papers on minimax adaptive control and estimation. Minimax adaptive estimation is a framework for output prediction and state estimation that provides a priori computable performance bounds for estimators. Minimax adaptive controllers ensure that the closed loop has finite gain, maintaining stability and performance under model class uncertainty.

The contributions of these papers are as follows: Paper I: Presents a minimax optimal output prediction algorithm for linear systems with parameter uncertainty. Paper II: Proposes an algorithm to compute performance bounds for minimax adaptive estimators. Paper III: Develops a minimax sub-

optimal adaptive controller for scalar linear systems with noisy measurements. Paper IV: Introduces a class of nonlinear systems for which minimax dual control admits a finite-dimensional sufficient statistic, builds dynamic programming theory around this class, and designs an adaptive controller for stabilizing an integrator from absolute-value measurements. Paper V: Provides a unified framework for state-feedback and output-feedback minimax adaptive control and methods for synthesizing suboptimal controllers. Complementing these theoretical contributions are two software artifacts: one for adaptive control and the other for adaptive estimation.

The contributions apply to simple systems that represent components of larger systems, marking a step towards automating controller synthesis and maintenance for critical infrastructures.



10 year period showing the number of dissertations including both Doctoral and Licentiate Theses

LICENTIATE DISSERTATION

This year there was one PhD student presenting his Licentiate Thesis. The abstract is presented below.

David Ohlin

POSITIVE NETWORK SYSTEMS: HEURISTIC METHODS AND OPINION DYNAMICS

Ohlin, David

The analysis of interconnected systems is a large and growing field, with successful applications in a wide range of natural and synthesized systems. Biomolecular networks, power grids and human social dynamics have all been the subject of study through the lens of network dynamics, with impressive results. The work presented in this thesis takes the form of four research papers all focusing in different ways on networks. These networks consist of simple systems, which interact to give rise to more complex dynamics. The first and second papers deal with methods for controlling interconnected positive linear systems in ways that remain viable as the scale of the system grows. In the third and fourth papers, models for opinion dynamics are constructed by extending existing linear and positive models, using nonlinearities to capture more complex behavior. Specifically, this enables asymptotic disagreement, or dissensus, between agents as the dynamics evolve.

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.

It 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 2024, ELLIIT organized two focus periods. One on *Security and Fault Tolerance of Cyber-Physical Systems* in Lund Apr 1 – May 3, organized by Martina Maggio and Mikael Asplund from Linköping University, and one on *Machine Learning for Climate Science* in Linköping Sep 23 – Oct 25. The focus periods unite young international scholars, ELLIIT researchers and other top international academics active in the relevant domains.

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, which ended January 2025, has been 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) has been 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 has brought 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 has been 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 and increase the ability of the Nordic nations to address European and global cooperation and competition in IIoT, as well as increasing their competitiveness and growth via research and innovation.

During the seven years that HI2OT has been running, a number of collaborations have been initiated, involving both PhD students and faculty. This includes a jointly written roadmap on Green IIoT. Currently the partners are involved in two EU proposals to the COST and MSCA-DN calls.

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 6.5 billion.

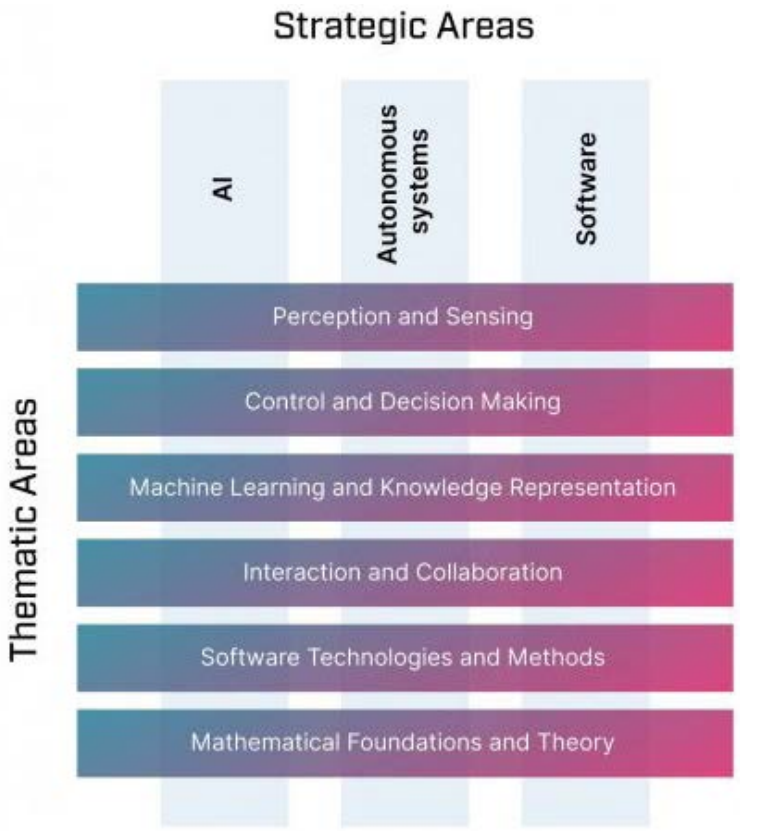
The graduate school within WASP is dedicated to providing the skills needed to analyze, develop, and contribute to the interdisciplinary area of AI, autonomous systems and software. The curriculum provides the foundations, perspectives, and state-of-the-art knowledge in the different disciplines taught 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 Ph.D students, researchers, and industry. The graduate school provides added value on top of the existing Ph.D 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, Deptartment of Computer Science, Department of Electrical and Information Technology, and the Mathematical Imaging Group at the Department of Mathematics.

During 2024, Amy Loutfi from Örebro University replaced Anders Ynnerman as director for WASP. Anders Ynnerman instead replaced Pontus de Laval as chairman of the board of WASP. During 2024 Karl-Erik Årzén and Martina Maggio arranged a WASP study trip to Italy and Karl-Erik Årzén co-arranged a cluster study trip to Silicon Valley.

At the beginning of 2025, WASP funds the following positions at our department: 13 academic PhD students, 4 industrial PhD students (with Saab Kockums*2, Boliden, and Ericsson), 5 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 eight Swedish universities: Chalmers University of Technology, KTH Royal Institute of Technology, Linköping University, Lund University, Umeå University, Örebro University, Uppsala University and Luleå University of Technology.

PROFILE AREAS' WORK CONTINUES

The Department of Automatic Control is involved in several of the different profile areas.

LUND UNIVERSITY PROFILE AREA

Out of the five Lund University profile areas — Automatic Control is involved in one of them, namely *Natural and Artificial Cognition*.

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 2024 the profile area received prolonged funding for at least another two years.

FACULTY OF ENGINEERING PROFILE AREAS

The faculty profile areas below have engagement from the Department of 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 AREAS

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 produced short films to be found on the department webpage.

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

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
- 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 Luapunov Analysis of Optimization Algorithms
- Scalable control for Electrical Power Systems
- Interpretable Safety and Performance Guarantees using Scaled Relative Graphs
- Synthesizing Second-Life Batteries for Grid Support: A Multidisciplinary Approach

SCALABLE CONTROL OF INTERCONNECTED SYSTEMS

Researchers: Rantzer, Anders; Pates, Richard; Agner, Felix; Grönqvist, Johan; Kjellqvist, Olle; Gurpegui Ramón, Alba; 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

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

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

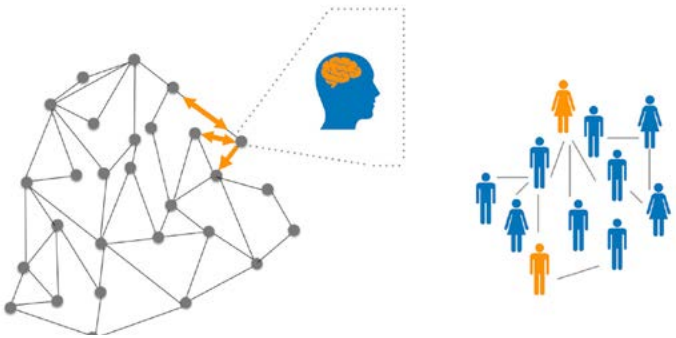
At the United Nations Summit 2015, our world leaders adopted 17 Sustainable Development Goals. A necessary condition for the completion of these goals is efficient, reliable, and safe infrastructure. For example, Goal 7: Affordable and Clean Energy requires infrastructure robust to loss of the inertia 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, Olle 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. Olle defended his Thesis in October 2024.

DYNAMICS OF COMPLEX SOCIO-TECHNOLOGICAL NETWORK SYSTEMS

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

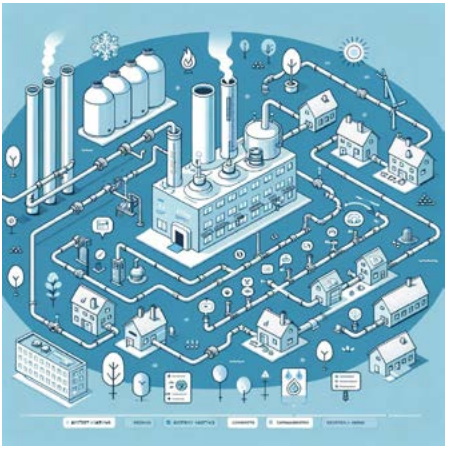
STATISTICAL AND ADVERSARIAL LEARNING IN CONTINUOUS SYSTEM CONTROL

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

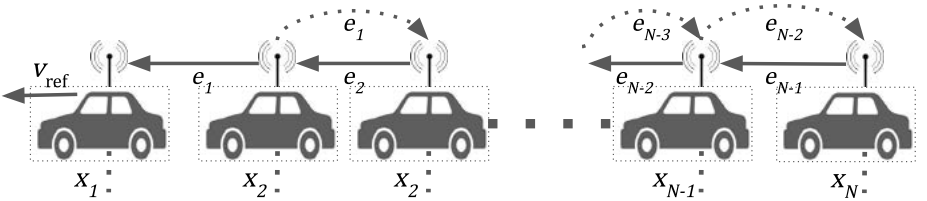
Researchers: Vladu, Emil; Rantzer, Anders; Pates, Richard
Funding: WASP and ERC

The research is in the field of large-scale dynamic networks, where applications include traffic networks, data networks and district heating networks. More specifically, we are interested in suppressing network disturbances of various kinds as efficiently as possible. In particular, we are interested in the case where nonlinearities, such as capacity constraints, occur.

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.

BREGMAN OPTIMIZATION ALGORITHMS

Researchers: 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.

OPTIMAL ESTIMATION AND CONTROL AT SCALE

Researchers: Pates, Richard; Adlercreutz, Julia
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.

MODEL PREDICTIVE CONTROL STABILITY ANALYSIS

Researchers: 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 LUAPUNOV 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.

SCALABLE CONTROL FOR ELECTRICAL POWER SYSTEMS

Researchers: Pates, Richard; Lindberg, Johan
Funding: ELLIIT

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 project explores the role of optimal control with respect to these issues, with a view towards generating insights, fundamental limitations, and novel control strategies, that can be used to help the design and operation of future smart electrical power systems.

SYNTHESIZING SECOND-LIFE BATTERIES FOR GRID SUPPORT: A MULTIDISCIPLINARY APPROACH

Researchers: Pates, Richard; Hällström, Ask
Funding: COMPEL research initiative

Batteries are central to supporting the renewable energy transition. However, there is a significant environmental and financial cost associated with the production of new batteries. The potential of repurposing retired batteries from various applications, such as electric vehicles, for use in areas like grid support, presents a unique and sustainable avenue to reduce these impacts and accelerate the use of batteries.

This project aims to explore the feasibility of assembling used batteries, no longer fit for their original purpose, to create 'new' batteries that can provide robust grid support. The basic idea is to connect many smaller, retired batteries to create a larger, heterogeneous battery. By exploiting advanced control theoretic techniques developed for interconnected heterogeneous systems, methods will be developed to quantify the capabilities and capacities of this hybrid battery, optimizing them for the new application domain.

INTERPRETABLE SAFETY AND PERFORMANCE GUARANTEES USING SCALED RELATIVE GRAPHS

Researchers: Pates, Richard; Nauta, Talitha

Ensuring the safety and reliability of autonomous systems is a fundamental challenge, particularly as they increasingly rely on complex, black box machine learning models. While such models provide exceptional predictive power, their lack of interpretability makes it difficult to guarantee robustness, especially in dynamic and uncertain environments. This project aims to develop new tools for analyzing and certifying the safety and performance of black box models, facilitating their integration into autonomous systems, using Scaled Relative Graphs as a unifying framework.

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:

- Robust and Secure Control over the Cloud
- Advanced Offloading for Real-Time Applications - AORTA
- Ad-hoc Compute Offloading for Autonomous Connected Vessels

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.

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.

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.

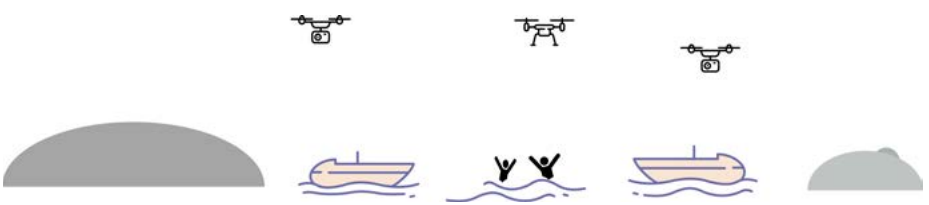


Figure: The project will target the WARA-PS rescue scenario, which involves a set of cooperating Connected drones and autonomous boats.

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 RobotLab LTH. 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 LTH
- Autonomous Flight (UAS@Lund)
- Autonomous Force-Aware Swift Motion Control
- Hand-arm coordination control for robotic interaction tasks
- Optimizing the Next Generation Brain Computer Interfaces using Cloud Computing
- Intelligent trajectory predictions at sea using neural ordinary differential equations
- Subsystem for two-coordinate positioning of the UAV auxiliary video camera
- Intelligent Cloud Robotics for Real-Time Manipulation at Scale
- Data-driven Modeling for Sustainable Mining
- Trustworthy Cyber-Physical Pipelines
- Historical Female Influencers in Automatic Control
- Learning Pharmacometric Model Structures from Data
- Whole-Body Interactive Mobile Manipulation
- CAISA - Collaborative Artificial Intelligent Surgical Assistance
- Functional ex vivo heart evaluation
- DYNACON: DYNamic Attack detection and mitigation for seCure autONomy
- NextG2Com

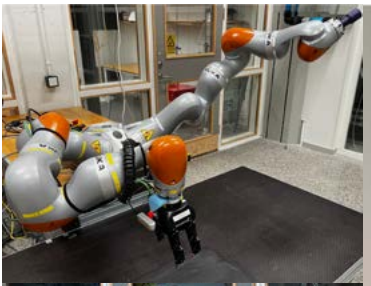
ROBOTLAB LTH INFRASTRUCTURE

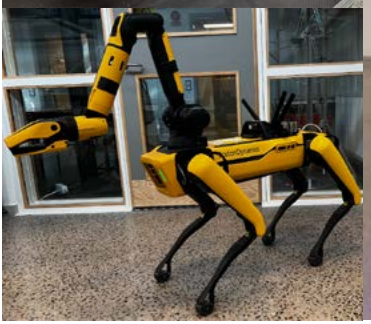
RobotLab LTH is a close collaboration between Deptartments of Automatic Control and Computer Science. Our main research is on autonomous robotic systems, with special focus on motion and compliance control, control and software system architectures, different sensor fusion problems, robot vision, and 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 e.g., 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.

During 2024, a dedicated 5G network was installed in the lab by Ericsson as part of the AORTA research project. The network is connected to the 5G/6G lab at the EIT department in the E-building, enabling edge computing and computational off-loading.

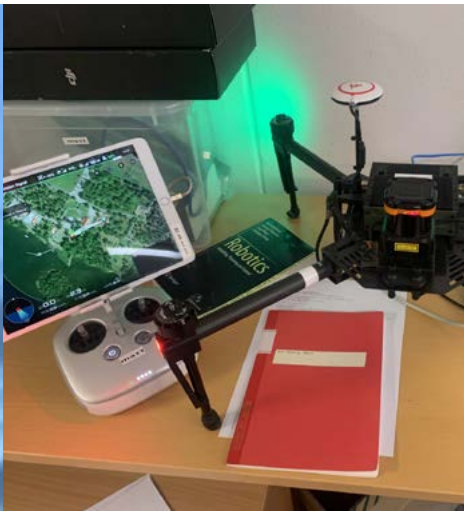




AUTONOMOUS FLIGHT (UAS@LUND)

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

This research project addresses and develops the technologies of unmanned flying systems (UAS) in order to make such systems more suitable for addressing various societal 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 Search-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 Department 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

Researchers: 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 nonholonomic 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.

INTELLIGENT TRAJECTORY PREDICTIONS AT SEA USING NEURAL ORDINARY DIFFERENTIAL EQUATIONS

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

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.

OPTIMIZING THE NEXT GENERATION BRAIN COMPUTER INTERFACES USING CLOUD COMPUTING

Researchers: Bernhardsson, Bo; Heskebeck, Frida; Bergeling, Carolina (BTH)
Funding: WASP

The project aims to improve EEG-based Brain Computer Interfaces (BCI) with machine learning, control, and cloud computing. 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.

SUBSYSTEM FOR TWO-COORDINATE POSITIONING OF THE UAV AUXILIARY VIDEO CAMERA

Researcher: Voitenko, Volodymyr
Funding: Crafoord Foundation and SARS (Scholars At Risk Sweden)

Unmanned aerial vehicles (UAVs) are used to surveil ground objects in many areas. UAVs deliver a video stream from an on-board video camera, which is normally read by an operator. Despite the successful attempts to expand the UAV autonomy, human operators remain important. They experience heavy information loads leading to omission of desired objects, fatigue, and diseases. Using an auxiliary video camera with a narrow viewing angle positioned independently of the main camera is a proposed solution to this problem. The 2DCAM project aims to develop theoretical foundations, software and hardware, and to experimentally verify the quasi-optimal positioning subsystem for the auxiliary video camera of the UAV based on the data from an on-board object detector. The project integrates knowledge from image processing, automatic control systems and mechatronics. Quasi-optimal controller empowers AI and changes the design paradigm of electromechanical systems.

The project lasts until July 1, 2025.

To solve the problem of fatigue of the UAV operator during long-term search and reconnaissance missions, a research hardware and software complex was created, in which the positioning of the additional UAV video camera with a narrow field of view is carried out. Dynamixel Library for MATLAB and Simulink was used to organize the interaction of actuators with the virtual environment, which allows combining positioning and image analysis subsystems in a single virtual environment. The results of an experimental study of the 2DCAM virtual-physical system are given.

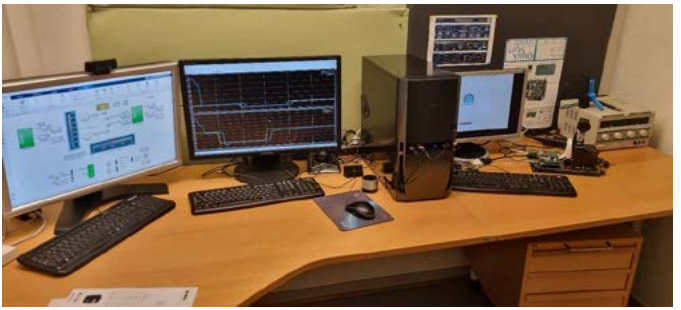


Fig.1. Software and hardware complex for experimental study of two-coordinate positioning system of additional UAV video camera

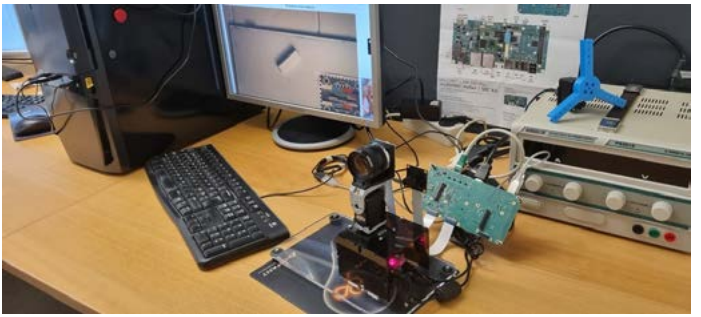


Fig. 2. Hardware part of the 2DCAM subsystem

INTELLIGENT CLOUD ROBOTICS FOR REAL-TIME MANIPULATION AT SCALE

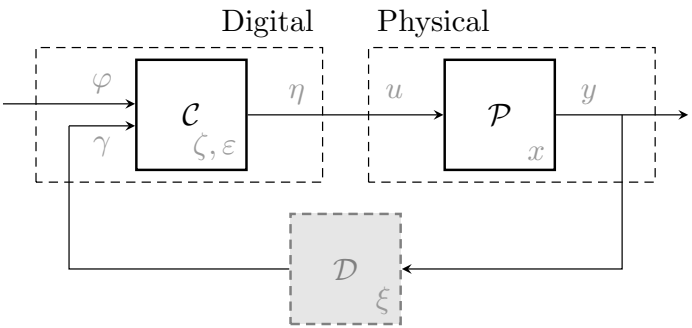
Researchers: Maggio, Martina; Sinnema, Yde
Funding: WASP

Machine learning based robotic manipulation approaches attempt to enable robotic systems to acquire manipulation skills using methods such as deep reinforcement learning. Data-driven approaches have emerged as a predominant paradigm in particular since noise, uncertainty and incomplete sensor data prohibit analytic modelling or perfect simulation of the robot-environment interaction in many scenarios. Unfortunately, however, no general purpose robot exists today that can reliably manipulate the wide variety of objects that humans interact with on a daily basis and conducting data-driven robotic manipulation research is costly and time-consuming since running real-world robotic experiments is error-prone and costly in terms of time and hardware. Research today is typically done on a single robot, resulting in current experimental setups having to rely on only a limited set of real-world training data which is still orders of magnitudes smaller than the amount of sensory data a human child gathers in the first few months after birth. Progress in fields such as computer vision and speech recognition however provides evidence that breakthroughs in machine learning-based methods require scale. In particular machine learning at scale e.g. via deep learning, training data at scale e.g. ImageNet, and infrastructure and parallelization at scale e.g. via cloud-computing.

We argue that robotic manipulation research is still starved for scale, which makes it difficult to obtain statistically reliable and repeatable results and has fundamentally hindered progress in this area. In our view, a concentrated cross-disciplinary Cloud.

Robotics effort towards robotic manipulation research is required to overcome these challenges and to unlock the potential of robotic automation beyond today's limited robotic manipulation applications.

To endow robotic systems with capabilities to reliably and safely grasp and manipulate the vast variety of objects encountered in both industrial and everyday home settings, significant interdisciplinary breakthroughs are required before such systems can be deployed. While machine learning relying on large scale image, text and audio data is progressing at rapid pace, robotic manipulation research has in comparison been starved for data since data acquisition on a single robotic system is expensive and slow. This project tackles challenges in this domain by focusing in particular on the emerging paradigm of Cloud Robotics, where robots can communicate over a network to share observations and jointly learn from past observations.



DATA-DRIVEN MODELING FOR SUSTAINABLE MINING

Researchers: 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

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

technology. Furthermore, the effect of the measured properties on the system state are often both 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.

TRUSTWORTHY CYBER-PHYSICAL PIPELINES

Researcher: Maggio, Martina
Funding: Swedish Research Council (VR)

Pipelines of tasks are ubiquitous. From automotive to avionics, a standard pattern for processing data and take decision is to read some input (possibly measuring some environmental variable), process the data, and the write to the output (possibly by actuating over the external environment). When these pipelines operate in a safety critical environment, the assurance of a correct functioning is of vital (in the true meaning of the term) importance. However, a correct prediction of delivery is not easy.

As an example of the jeopardy of the problem, in 2021 NASA reported an anomaly during the sixth flight of the Ingenuity helicopter of the Mars Perseverance rover. While in the air, Ingenuity began adjusting its velocity and tilting back and forth in an oscillating pattern. Ingenuity used a pipeline of sensor data, that include inertial measurement units and cameras to estimate its position.

Quoting from the report: "Approximately 54 seconds into the flight, a glitch occurred in the pipeline of images being delivered by the navigation camera. This glitch caused a single image to be lost, but more importantly, it resulted in all later navigation images being delivered with inaccurate timestamps. From this point on, each time the navigation algorithm performed a correction based on a navigation image, it was operating on the basis of incorrect information about when the image was taken. The resulting inconsistencies significantly degraded the information used to fly the helicopter, leading to estimates being constantly corrected to account for phantom errors. Large oscillations ensued."

In the project, we work on verification techniques for cyber-physical systems and make them available through open source tools. The basic research behind the project requires a significant innovation that is far from obvious to establish, because of the intertwining of discrete and continuous dynamics, as well as involving the timing of the computations.

HISTORICAL FEMALE INFLUENCERS IN AUTOMATIC CONTROL

Researchers: Johnsson, Charlotta; Westin, Eva; Hägglund, Tore; Soltesz, Kristian; Bauer, Margret
Funding: IFAC Activity Fund, Dept. of Automatic Control, ELLIIT, IEEE

The aim of this initiative is to gather a collection of portraits of women who worked in control engineering over the decades and left their mark. The purpose is to document their role and importance in the field of control engineering and to highlight the role of women for today's students.

There are some early female historical influencers (retired or emeritus female professionals) who have served as role models in the field of automatic control.

A role model is a person who serves as an example by influencing others, and inspiring others to imitate his or her behavior. When we are young and grow up, the role model is usually an elder person, someone who we admire. Often it is a parent, a teacher, a sibling or an elder friend that is that person that we look up to and, intentionally or unintentionally, get inspiration from. As we grow elder, and start to shape our working-life, it becomes important to have professional role models, someone that we can identify ourselves with, someone that demonstrates, in a good way, how our working life could be. Having them pushes us to make the most out of our working life. It is interesting to look at the presence of role models in the control community. The elder professionals in this field, influences 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. One other example is in the everyday working environment e.g. laboratories or offices, where histories and anecdotes 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. Shows that only 11 out of the 128 PhD theses, thoughout its 60 years of history, are written by women. Statistics also show that only 14% of the PhD-students, and 9% of the professors are of female gender. These numbers are very low. Most probably the statistics from control department in other corners of the world, are very similar. Could it be that female rolemodels are missing?

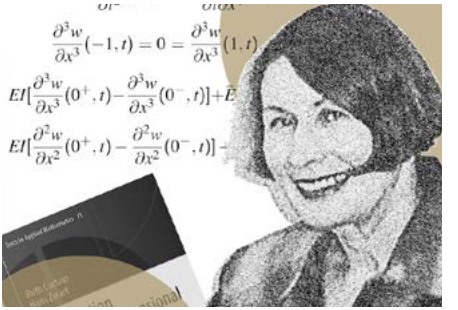
It is noted that early pioneers that are highlighted in basic control courses often (always?) are men e.g. Bode, Nyquist, Kalman, etc. Also, award winners are to a very large degree men, e.g. Richard E Bellman Award was given to a man 40 years in a row. This has an explanation in the fact that there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

The portrait series of these women can be used in various outreach material such as e.g. lecture notes, and other inspirational material for young and potential future control professionals. The interviews will also serve as input material to an academic paper presented to be submitted to a suitable control journal.

The primary purpose is to produce material that highlights historical female control pioneers (i.e. early role-models). The general thought is that everyone in the field will benefit from a more gender equal field. The field cannot reach its full potential, when a big portion of the contributors are not finding their way in to the field. Therefore, the material will be of importance to the field in itself. However, the material will find an additional purpose amongst young, female, and promising potential candidates, that today have a difficulty in finding anyone to identify with in field of Automatic Control.

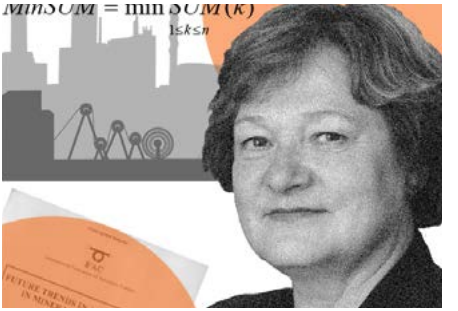
During 2024, the project was presented, both orally and via an exhibition, at several international conferences.

Maria Domenica Di Benedetto

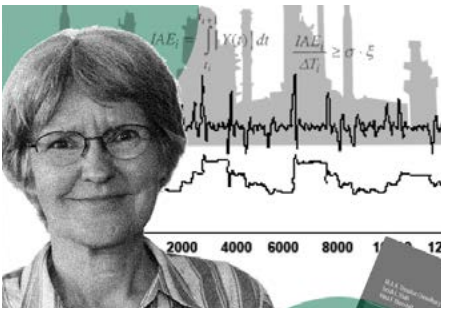


Ruth Curtain

Sofya Kovalevskaya



Sirkka-Liisa Jämsä-Jounela



Nina Thornhill

Irmgard Flügge-Lotz

Bozenna Pasik-Duncan

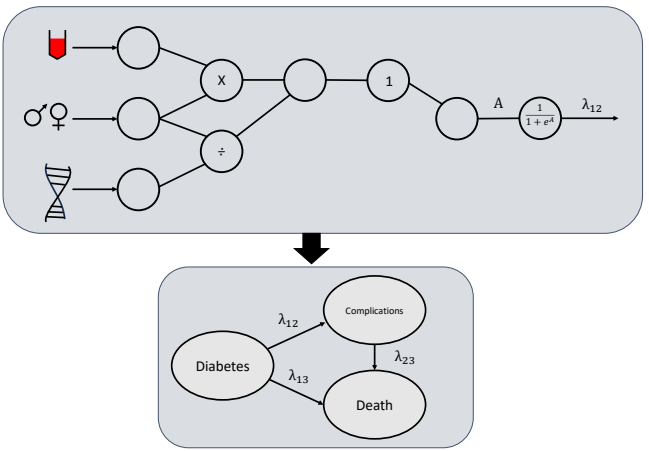
Eveline Gottzein

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.



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

WHOLE-BODY INTERACTIVE MOBILE MANIPULATION

Researchers: Fregnan, Sebastiano; Karayiannidis, Yiannis; Olofsson, Björn
Funding: WASP WARA-Robotics

A mobile manipulator combines the unlimited workspace of a mobile platform with the multiple functionalities of a manipulator, thus providing a flexible system that have the potential to revolutionize various industries, including logistics, manufacturing, construction, and search-and-rescue operations. Despite the enormous potential for a wide range of industries and recent advances in mobile manipulation, there are several challenges that impede the widespread adoption of mobile manipulators. Besides, for the majority of mobile manipulators deployed in industrial floors and academic labs, the mobility of the platform and the manipulator are not treated in a whole-body fashion, i.e., the mobile robot moves to specific positions while the manipulator is not moving and when the manipulator performs a task the platform remains still. To achieve the full potential of mobile manipulation, the simultaneous motion and interaction of the platform and the arm needs to be considered.

The key idea of the PhD project is to endow mobile manipulators with whole-body mobility and interaction functionalities that are based on coordinated control of the mobile platform and the mounted robotic manipulator and address performance, reliability, and safety. The main objective of the project is to establish a constrained control framework for composite platform-manipulator motion and design adaptive whole-body compliant control for interaction with objects and the environment. The main platform designed to be used in the project is an ABB YuMi robot mounted on Sleipner, a mobile robot of the RobotLab LTH.

CAISA - COLLABORATIVE ARTIFICIAL INTELLIGENT SURGICAL ASSISTANT

Researchers: Stenmark, Maj; Johnsson, Charlotta in collaborations with Cognibotics and Skåne University Hospital
Funding: Swedish Government Agency for Innovation Systems (Vinnova)

In a multidisciplinary close collaboration (of surgeons, nurses, and experts in AI and Robotic Control) we want to begin the transfer of surgical know-how (both cognitive and manual) from human to machine, build a prototype, demonstrate proof-of-concept and drive the development in the direction of safe and autonomous surgical robotics.

To replace the human surgeons, we need Advanced Robotic Control. For surgical purposes, this control must be based on short (<200 ms) loops of Sense-Plan-Act.

For sense, Computer Vision, specifically 6D OPE algorithms will be used to map all relevant physical objects, including patient anatomy, surgical equipment, and operating theatre staff.

For plan, Reinforced Learning will be applied. Expert surgeons will annotate good vs bad plans for a given trajectory of motions at a given situation.

For act, Dynamic Movement Primitive algorithms will be applied to capture, copy and smoothen surgical motions from segmentations by 6D OPE. Transformer models are an alternatives that will explored, but will requiew larger datasets.

For these innovations to reach clinical use, reliable human-machine communication protocol must be developed. The robot system must visualize, by means of a laser marker or projected lines on to the surgical field to describe the planned trajectory of cut, suturing or other actions.

FUNCTIONAL EX VIVO HEART EVALUATION

Researchers: Soltesz, Kristian; Pigot, Henry (Harry); Nilsson, Johan, AIBCTS
Funding: Mats Paulssons Foundation and Hjelm Family Foundation

In this project we conceptualize, develop and refine a cyber-physical device that emulates vascular dynamics. It is connected to an isolated heart, and enables evaluation of the organ outside of the body, under user-specified work load conditions.

Together with clinical and corporate research collaborators, we adapt the technology to the clinical setting.

DYNAMIC ATTACK DETECTION AND MITIGATION FOR SECURE AUTONOMY

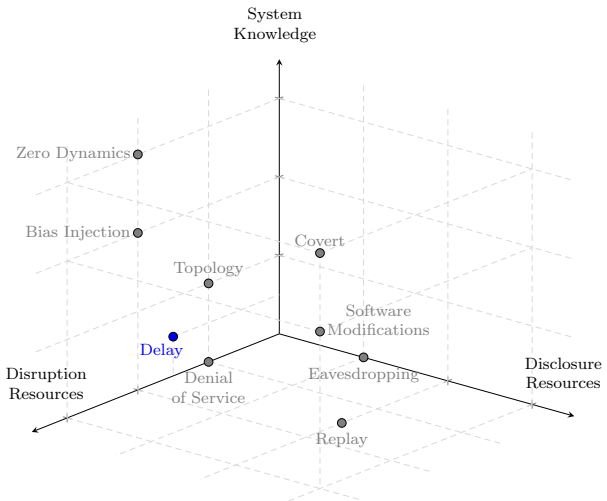
Researcher: Maggio, Martina
Funding: WASP-NEST

Control systems are at the heart of many indispensable societal functions, from energy distribution to pacemakers. Although we rely on these systems, cyber-physical controllers have been increasingly targeted by cyber attacks, from critical infrastructures such as power grids to commercial devices.

Many types of attacks on cyber-physical systems (CPSs) exist, e.g., where sensor or actuator data can be compromised or the transmission channel can be impaired. A remote adversary can through software vulnerabilities gain the ability to execute arbitrary code on a CPS. The attacker can then utilize different techniques to elevate its privilege and get full control of the device. The urgency of considering attacks on CPSs is also witnessed by the recent publication of the MITRE Attack ICS framework.

Cyber-physical control systems normally belong to one of three broad classes: bare-metal applications, embedded systems executing control functions alongside a real-time operating system, and general purpose computers running full-fledged operating systems. In this NEST proposal, we focus on the second of these classes and target embedded systems that execute a real-time operating system. This is the setting of many control applications, from automotive to avionics. Common to control systems is that they are designed to reject physical disturbances and to be fault tolerant. Cyber attackers are more challenging to face in that they can adapt and learn to achieve strategic objectives, in contrast to disturbances and faults, which are random and hard to predict in advance. Our concern is that such attacks in the cyber layer of the control system may cause severe physical damage and violate strict safety constraints, making mitigation strategies and countermeasures essential for the development of future control systems.

The aim of this NEST proposal is to develop theory and rigorous tools for defense against cyber attacks on dynamical physical systems with time-critical controllers. We specifically target systems with a high degree of autonomy, such as drones. However, the results that we will develop are relevant in general to any multi-agent system with limited computational resources.



The figure represents a taxonomy of attacks, and positions our attack, the delay attack. The attacker ensures that the controller calculations are not completed on time, in an attempt to maximize the disruption that the system experiences

NEXTG2COM

Researchers: Johnsson, Charlotta in collaboration with researchers at the Faculty of Engineering at Lund University
Funding: Vinnova in the Avancerad Digitalisering program, and The Faculty of Engineering at Lund University, Volvo Cars, Tetra Pak, Ericsson, Sony, Region Skåne, Acconeer AB, Allicon AB, Bosch, CodeScene, Cognibotics, GUARDBOT INC, RemotiveLabs, Sensative, Swedish Sea Rescue Society, and u-blox.

The new competence center on Next Generation Communication and Computing Infrastructures and Applications (NextG2Com) is now up and running after the kick-off May 30 at The Faculty of Engineering at Lund University in Teknodromen.

The 16 partners from academia, industry and the public sector spent a full day getting an introduction to the center and discussing the collaborative research and innovation program, organized in six themes, ranging from wireless communication to software and data. We plan for five years of research and set out for 10. The first step is to recruit five PhD students.

Our vision is to set a distinct footprint in the design of next generation communication and computational infrastructures and applications, nationally and internationally. In particular, we will focus on the interplay between infrastructure and applications, and developments driven by and needed for machine learning (ML) advancements. Through integrated industry–academia research we will advance infrastructure technologies and design methodologies, communicate knowledge into industry practice through proof-of-concepts, demonstrators and targeted outreach, and we will strengthen basic and advanced education.

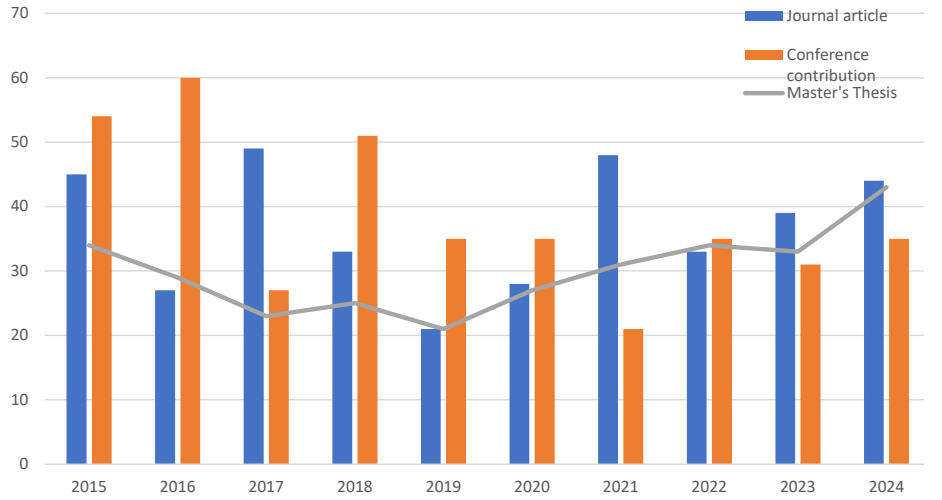


Publications and seminars

This chapter contains a list of publications and seminars during 2024

PUBLICATIONS 2024

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, also be borrowed through the library service.



BOOKS

Guzman, Josè Luis and Hägglund, Tore; *Feedforward Control: Analysis, Design, Tuning rules, and Implementation.* In De Gruyter Textbook.

Soltesz, Kristian; *Dynamical modeling of physiology.*

JOURNAL ARTICLES

Agner, Felix; Hansson, Jonas; Kergus, Pauline; Rantzer, Anders; Tarbouriech, Sophie and Zaccarian, Luca; *Decentralized PI-control and Anti-windup in Resource Sharing Networks.* In European Journal of Control 80.

Agner, Felix; Møller Jensen, Christian; Rantzer, Anders; Skovmose Kallesøe, Carsten and Wisnievski, Rafal; *Hydraulic Parameter Estimation for District Heating Based on Laboratory Experiments.* In Energy.

Agner, Felix and Rantzer, Anders; *On PI-control in Capacity-Limited Networks.* In Automatica.

Arditti, Laura; Como, Giacomo; Fagnani, Fabio and Vanelli, Martina; *Robust Coordination of Linear Threshold Dynamics on Directed Weighted Networks.* In IEEE Transactions on Automatic Control 69(10). p.6515-6529.

Arditti, Laura; Como, Giacomo and Fagnani, Fabio; *On the Separability of Functions and Games.* In IEEE Transactions on Control of Network Systems 11(2). p.831-841.

Arslan Waltersson, Gabriel and Karayiannidis, Yiannis; *Planar Friction Modeling With LuGre Dynamics and Limit Surfaces.* 40th Anniversary of the IEEE International Conference on Robotics and Automation In IEEE Transactions on Robotics 40. p.3166-3180.

Bakovic, Luka; Ohlin, David; Como, Giacomo and Tegling, Emma; *Multipolar Opinion Evolution in Biased Networks.* In IEEE Control Systems Letters 8. p.1054-1059.

Banert, Sebastian; Rudzusika, Jevgenija; Öktem, Ozan and Adler, Jonas; *Accelerated Forward-Backward Optimization Using Deep Learning.* In SIAM Journal on Optimization 34(2). p.1236-1263.

Bauer, Margret; Norlund, Frida; Westin, Eva and Knorn, Steffi; *Navigating Language and Terminology in Automatic Control Literature.* 4th IFAC Conference on Advances in Proportional-Integral-Derivative Control In IFAC Proceedings Volumes (IFAC-PapersOnline).

Bencherki, Fethi and Rantzer, Anders; *Data-Driven Adaptive Dispatching Policies for Processing Networks.* In IEEE Control Systems Letters 8.

García-Mañas, Francisco; Hägglund, Tore; Guzmán, José Luis; Rodríguez, Francisco and Berenguel, Manuel; *A practical solution for multivariable control of temperature and humidity in greenhouses.* In European Journal of Control 77.

Grommisch, David; Wang, Menghan; Eenjes, Evelien; Svetlcic, Maja; Deng, Qiaolin; Giselsson, Pontus and Genander, Maria; *Defining the contribution of Troy-positive progenitor cells to the mouse esophageal epithelium.* In Developmental Cell 59(10). p.6-1283.

Guzmán, José Luis; Zakova, Katarina; Craig, Ian; Hägglund, Tore; Rivera, Daniel E.; Normey-Rico, Julio; Moura-Oliveira, Paulo; Wang, Liuping; Serbezov, Atanas and Sato, Takao, et al; *An International Overview of Teaching Control Systems During COVID-19 Pandemic.* In International Journal of Engineering Education 40(5). p.1162-1180.

Guzmán, J. L. and Hägglund, T.; *Tuning rules for feedforward control from measurable disturbances combined with PID control : a review.* In International Journal of Control 97(1). p.2-15.

Hansson, Jonas and Tegling, Emma; *Performance bounds for multi-vehicle networks with local integrators.* In IEEE Control Systems Letters 8. p.2901-2906.

Hoyo, Ángeles; Guzmán, José Luis; Moreno, José Carlos and Hägglund, Tore; *Double feedforward compensation for cascade control schemes.* In Computers and Chemical Engineering 181.

Jouini, Taouba and Dorfler, Florian; *Parametric local stability condition of a multi-converter system.* In IEEE Transactions on Automatic Control.

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Kjellqvist, Olle; *Minimax Adaptive Control and Estimation.* PhD Thesis, Department of Automatic Control, Lund University, Sweden, October 2024.

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Åkesson, Noah Eric Johnny; *Optimization of Electricity Resources on the Swedish Electricity Market.* Master's Thesis TFRT-6261. Supervisors: Giselsson, Pontus; Nilsson, Max and Lindberg, Johan, Department of Automatic Control, Lund University.

Al Bayati, Ahmed; *Dynamic Offloading of Control Algorithms to the Edge using 5G and WebAssembly.* Master's Thesis TFRT-6231. Supervisors: Årzén, Karl-Erik and Eker, Johan, Department of Automatic Control, Lund University.

Almgren, Klara and Mentzer, Annie; *Neural Speech Tracking in EEG: Integrating Acoustics and Linguistics for Hearing Aid Users.* Master's Thesis TFRT-6243. Supervisors: Alickovic, Emina; Skoglund, Martin (external); Bernhardsson, Bo and Giselsson, Pontus, Department of Automatic Control, Lund University.

Andersson, Anthon and Håkansson, Anton*; Flexible Computer Vision based Sample Switching System using a Robotic Arm.* Master's Thesis TFRT-6247. Supervisors: Brys, Tomasz; Rathsman, Karin (external) Olofsson, Björn and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

Andersson, Axel and Hallerfelt, Nils; *Data Augmentation for Object Detection using Deep Reinforcement Learning.* Master's Thesis TFRT-6225. Supervisors: Göransson, Robin; Sjöbom, Joel (external) Heimerson, Albin and Eker, Johan, Department of Automatic Control, Lund University.

Åstrand, Teodor; *Robot Reinforcement Learning for Object Isolation.* Master's Thesis TFRT-6255. Supervisors: Olofsson, Björn and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

Azarnoush, Faraz and Sabotic, Dami; *Using Synthetic Data For Object Detection on the edge in Hazardous Environments.* Master's Thesis TFRT-6221. Supervisors: Sankari, Ghaith (external); Agner, Felix and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Bai, Jingmo and Yu, Zuoyi; *Detection and Tracking of Soil Protists using Deep Learning.*Master's Thesis TFRT-6239. Supervisors: Hammer, Edith, Zou, Hanbang (external); Bernhardsson, Bo and Eker, Johan, Yiannis, Department of Automatic Control, Lund University.

Bakklund, Joakim; *Local voltage control in a low voltage grid with high photovoltaic penetration.* Master's Thesis TFRT-6226. Supervisors: Pettersson, Thomas (external); Pates, Richard and Tegling, Emma, Department of Automatic Control, Lund University.

Balan, Patric and Jönemo, Gustav; *Predicting Navigational Patterns in Web Applications using Machine Learning Techniques.* Master's Thesis TFRT-6224. Supervisors: Olsson, Albin (external) Årzén, Karl-Erik and Eker, Johan, Department of Automatic Control, Lund University.

Carrillo Sala, Antoni; *Physics-Informed Reinforcement Learning Feasibility Study for Building Energy Optimization.* Master's Thesis TFRT-6246. Supervisors: Åkesson, Johan (external); Bernhardsson, Bo and Rantzer, Anders, Department of Automatic Control, Lund University.

Celoria, Alessandro and López, Valentín; *An ASR-based Hybrid Approach for Auditory Attention Decoding.* Master's Thesis TFRT-6233. Supervisors: Alickovic, Emina; Skoglund, Martin (external); Bernhardsson, Bo and Giselsson, Pontus, Department of Automatic Control, Lund University.

Clarke Nilsson, Oscar and Relander, Ossian; *Systemic Risk and Default Contagion in Financial Networks: Identifying Systemically Important Banks.* Master's Thesis TFRT-6240. Supervisors: Como, Giacomo and Tegling, Emma, Department of Automatic Control, Lund University.

Dang, Van Duy and Elessawi, Basim; *Improving Temperature Estimation Models using Machine Learning Techniques.* Master's Thesis TFRT-6229. Supervisors: Rönn, Meike; Hörberg, Arne (external) Bernhardsson, Bo and Pates, Richard, Department of Automatic Control, Lund University.

Donck, Ewoud; *Distributed Reinforcement Learning for Building Energy Optimization.* Master's Thesis TFRT-6252. Supervisors: Åkesson, Johan (external) Giselsson, Pontus and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Forsell, Anton; *Reinforcement learning for optimal control problems in continuous time and space.* Master's Thesis TFRT-6258. Supervisors: Rantzer, Anders and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

Fredlund, Björn; *Design, Implementation and Evaluation of a Fault Detection and Emergency Control Strategy for a Quadcopter System.* Master's Thesis TFRT-6257. Supervisors:: Antonsson, Tobias; McGuire, Kimberly (external), Jia, Zheng, Olofsson, Björn and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Gummesson Atroshi, Oscar and Sibai, Osman; *Deep hedging of CVA.* Master's Thesis TFRT-6253. Supervisors: Zhu,Shengyao (external), Wiktorsson, Magnus; Upadhyaya, Manu and Eker, Johan, Department of Automatic Control, Lund University.

Hallabro, Ludvig and Rinderud, Jacob; *Embedded Model Predictive Control in ABB's Distributed Control System: A qpOASES-Based Approach.* Master's Thesis TFRT-6251. Supervisors: Theorin, Alfred (external) Kjellqvist, Olle and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Häggström Wedding, Johanna and Thunborg, Ella; *Robotised Guard Tours in Security Systems.* Master's Thesis TFRT-6237. Supervisors: Haage, Mathias; Olofsson, Björn and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Hällström, Ask; *On the advantages of heterogeneity in the bidirectional control of platoons.* Master's Thesis TFRT-6245. Supervisors: Pates, Richard and Rantzer, Anders, Department of Automatic Control, Lund University.

Hamadi Liafichev, Aslan and Magnusson, Albin; *Robotic System for Automatic Dispensing and Cutting of Rubber Cord Into a Compression Mold.* Master's Thesis TFRT-6256. Supervisors: Persson, Gustav (external); Olofsson, Björn and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

Javeed, Arshad; *Distributed Reinforcement Learning for Building Energy Optimization.* Master's Thesis TFRT-6242. Supervisors: Åkesson, Johan (external); Bernhardsson, Bo and Giselsson, Pontus, Department of Automatic Control, Lund University.

Johansson, Oscar; *Improving the Efficiency of a Pulp Bleaching Plant through Data-Based Modeling.* Master's Thesis TFRT-6244. Supervisors: Nilsson, David (external) Kjellqvist, Olle and Bernhardsson, Bo, Department of Automatic Control, Lund University.

Johansson Elmér, Hans; *On Persistent Noise in Distributed Averaging Dynamics.* Master's Thesis TFRT-6228. Supervisors: Como, Giacomo and Tegling, Emma, Department of Automatic Control, Lund University.

Karlsson, David; *A case study of SCADA implementation for small electrical producers in WideQuick* Master's Thesis TFRT-6223. Supervisors: Vikstrand, Johan; Kvist, Marcus (external); Johnsson, Charlotta and Tegling, Emma, Karl-Erik, Department of Automatic Control, Lund University.

Källander, Ivar and Swirski, Stanislaw; *Graph Attention Network-Based Monitoring of Complex Operational Systems.* Master's Thesis TFRT-6249. Supervisors: Lindberg, Mikael (external); Eker, Johan and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Lindbom, Frida and Petersson, Jakob; *Advanced Driver Assistance System (ADAS) for an Ultra-light Electric Vehicle.* Master's Thesis TFRT-6248. Supervisors: Bergkvist, Hannes (external); Olofsson, Björn and and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

Löfgren, Philip and Bengtsson, Tobias; *Powerbank Regulator For PoE Loudspeakers.* Master's Thesis TFRT-6238. Supervisors: Liljeblad, Eric; Forsberg, Christoffer (external); Johnsson, Charlotta and Rantzer, Anders, Department of Automatic Control, Lund University.

Magnúsdóttir, Heiðrún Dís; *Development and Evaluation of a Machine-Learning Based Fall Detection System for Prosthetic Knees.*Master's Thesis TFRT-6236. Supervisors: Páll Sigurþórsson, Stefán (external); Bernhardsson, Bo and Soltesz, Kristian, Department of Automatic Control, Lund University.

Martinsson, Victor; *Angular Velocity Estimation for Sensorless Brushless DC Motors.* Master's Thesis TFRT-6241. Supervisors: Svendenius, Jacob; Ströberg, Bertil (external); Soltesz, Kristian and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Murphy, Adrian and Larsson, Daniel; *Towards Automated Log Message Embeddings for Anomaly Detection.* Master's Thesis TFRT-6222. Supervisors: Angelsmark, Ola; Söderlund, Fanny (external); Eker, Johan and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Nyström, Anton; *Understanding Probabilistic Uncertainty Using v-Gap.* Master's Thesis TFRT-6230. Supervisors: Renganathan, Venkatraman and Rantzer, Anders, Department of Automatic Control, Lund University.

Péter, Ádám and Werner, Samuel; *The Impact of Unified Namespace in Industry 4.0.* Master's Thesis TFRT-6254. Supervisors: Lindqvist, Nils; Molin, Jens (external); Jeppsson, Ulf; Johnsson, Charlotta, Department of Automatic Control, Lund University.

Rannaleet, David and Gunnarsson, Victor; *Diffusion Modelling approaches to EEG-based Auditory Attention Decoding.* Master's Thesis TFRT-6227. Supervisors: Alickovic, Emina; Skoglund, Martin (external); Bernhardsson, Bo and Giselsson, Pontus, Department of Automatic Control, Lund University.

Rosenbäck, Max and Salehi, Frida; *Control Analysis of Active Dynamic Filtering Systems for Electrical Power Application.* Master's Thesis TFRT-6234. Supervisors: Lundström (external) and Pates, Richard; Rantzer, Anders, Department of Automatic Control, Lund University.

Ryhede Bengtsson, Bernard and Bengs, Joel; *Accelerated Segmentation with Mixed-Precision Quantization of EfficientViT-SAM.* Master's Thesis TFRT-6250. Supervisors: Bastani, Saeed; Guler, Puren (external); Giselsson, Pontus and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Sridhar, Gautam and Boselli, Sofía; *Auditory Attention Classification with Contrastive Learning.* Master's Thesis TFRT-6235. Supervisors: Alickovic, Emina; Skoglund, Martin (external); Bernhardsson, Bo and Giselsson, Pontus, Department of Automatic Control, Lund University.

Shahin, Abdullah; *Advanced Pulse Processing and Crosstalk Mitigation in X-ray Microcalorimeters.* Master's Thesis TFRT-6259. Supervisors: Uhlig, Jens and Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Sundin, Johan and Särud, Linus; *AI-driven Log Analysis for Intrusion Detection.* Master's Thesis TFRT-6232. Supervisors: Angelsmark, Ola; Söderlund, Fanny (external) and Eker, Johan; Årzén, Karl-Erik, Department of Automatic Control, Lund University.

Van Ommeslaeghe, Anna; *Microfactory robot cell for local element assembly in wooden prefab house manufacturing.* Master's Thesis TFRT-6260. Supervisors: Haage, Mathias and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

Westholm, Teodor; *Elasto-kinematic modelling and calibration of industrial manipulators with coupled wrist gearboxes.* Master's Thesis TFRT-6262. Supervisors: Stolt, Andreas (external); Olofsson, Björn and Karayiannidis, Yiannis, Department of Automatic Control, Lund University.

BACHELOR THESIS

Swartling Sennhed, Johan; *On Dynamic Stubbornness in the Concatenated Friedkin-Johnsen Model.* Batchelor's Thesis TFRT-7669. Supervisors: Tegling, Emma; Ohlin, David and Como, Giacomo, Department of Automatic Control, Lund University.

MISCELLANEOUS

Laban, Lara; Wzorek, Mariusz; Rudol, Piotr and Persson, Tommy; *Custom Non-Linear Model Predictive Control for Obstacle Avoidance in Indoor and Outdoor Environments.*

Wu, Dongjun and Rantzer, Anders; *Optimal Mass Transport of Nonlinear Systems under Input and Density Constraints.*

Wu, Dongjun LU and Rantzer, Anders; *Duality-based Dynamical Optimal Transport of Discrete Time Systems.*

SEMINARS AT THE DEPARTMENT

January

15 Seminar: *New support for innovation at Lund University*, Lisa Evyr and Thomas Rundqvist from LU innovation.
17 Master's Thesis Presentation: *A case study of SCADA implementation for small electrical producers, in WideQuick,* David Karlsson, LTH.
24 Master's Thesis Presention: *Towards Automated Log Message Embeddings for Anomaly Detection,* Adrian Murphy and Daniel Larsson, LTH.
25 Master's Thesis Presention: *Data Augmentation for Object Detection using Deep Reinforcement Learning,* Nils Hallerfelt and Axel Andersson. LTH.

Febuary

07 AI Lund lunch seminar: *On Calibration algorithms for real-time brain-computer interfaces,* Frida Heskebeck, PhD student Automatic Control, Lund University.
16 Master's Thesis Presentation: *Dynamic Offloading of Control Algorithms to the Edge using 5G and WebAssembly,* Ahmed Albayati, LTH.
16 Master's Thesis Presentation: *Predicting Navigational Patterns in Web Applications using Machine Learning Techniques*, Patric Balan and Gustav Jönemo, LTH.
16 Master's Thesis Presentation: *Diffusion Modelling approaches to EEG-based Auditory Attention Decoding*, David Rannaleet and Victor Gunnarsson, LTH.
20 LTH AI and Digitalization Seminar: *AI and Digitalization for the Process Industry*, Margret Bauer from Department of Automatic Control, LTH.

March

06 AI Lund lunch seminar: GPT in examination - experience report and experiment design Felix Agner, Julia Adlercreutz and Johan Grönqvist, PhD students, Automatic Control, Lund University. LTH.
14 Seminar: *ShorterRelay Test … Better PID Tuning*, Prof. Robin De Keyser, Ghent University.
15 Doctoral Thesis Defence: *Afterload system design for functional donor heart assessment,* Henry Pigot, LTH. Opponent: Professor John Bagterp Jørgensen, DTU.
19 AID Breakfast Seminar: *The path to autonomous robots in the operating room: technical, social and legal challenges*, Maj Stenmark.

April

03 Seminar by visiting scholars of the ELLIIT Focus Period Lund 2024: *Security and Fault Tolerance of Cyber-Physical Systems,* Marc Seidel, University of Stuttgart; Mohammad Hamad, TU Munich; Zeeshan Afzal, Linköping University.
04 Seminar by visiting scholars of the ELLIIT Focus Period Lund 2024: *Security and Fault Tolerance of Cyber-Physical Systems*, Rijad Alisic, KTH; Yankai Lin, TU Eindhoven; Melanie Gallant, Bosch GmbH.
05 Seminar by visiting scholars of the ELLIIT Focus Period Lund 2024: *Security and Fault Tolerance of Cyber-Physical Systems*, Raffaele Romagnoli, Carnegie Mellon University; Sebastian Schlor, University of Stuttgart.
08 Seminar: *A Closed-Loop System for Blood Pressure Control*, Taylor Baum, MIT, USA.

09 Seminar by visiting scholars of the ELLIIT Focus Period Lund 2024: *Security and Fault Tolerance of Cyber-Physical Systems*, Lena Becker, University of Saarland; Talitha Nauta, LTH.
15 ELLIIT three-day Symposium: *Security and Fault Tolerance of Cyber-Physical Systems.*
23 Seminar by visiting scholars of the ELLIIT Focus Period Lund 2024: *Security and Fault Tolerance of Cyber-Physical Systems*, Shiyong Zhu, City University of Hong Kong; Mojtaba Kaheni, Mälardalen University; Luis Burbano, University of California Santa Cruz.
24 Seminar by visiting scholars of the ELLIIT Focus Period Lund 2024: *Security and Fault Tolerance of Cyber-Physical Systems*, Sribalaji C. Anand, Uppsala University; Aneet Kumar Dutta, CISPA Helmholtz Center for information Security; Yifan Xie, University of Stuttgart.
25 Seminar by visiting scholars of the ELLIIT Focus Period Lund 2024: *Security and Fault Tolerance of Cyber-Physical Systems*, Satya Prakash Nayak, Max Planck Institute for Software Systems; Daniel Selvaratnam, KTH; Tung Nguyen, Uppsala University.
26 Seminar by visiting scholars of the ELLIIT Focus Period Lund 2024: *Security and Fault Tolerance of Cyber-Physical Systems*, Pablo Picazo-Sanchez, Halmstad University; Rijad Alisic, KTH.

May

13 Master's Thesis Presentation: *Improving the Efficiency of a Pulp Bleaching Plant through Data-Based Modeling*, Oscar Johansson, LTH.
16 AI* Nordic Powwow 2024 in Lund.
21 Master's Thesis Presentation: *Microfactory robot cell for local element assembly in wooden prefab house manufacturing*, Anna van Ommeslaeghe, LTH.
24 Master's Thesis Presentation: *Understanding Probabilistic Uncertainty Using Nu-Gap*, Anton Nyström, LTH.
27 Master's Thesis Presentation: *Development and Evaluation of a Machine-Learning Based Fall Detection System for Prosthetic Knees*, Heiðrún Dís Magnúsdóttir, LTH.
28 Master's Thesis Presentation: *Control Analysis of Active Dynamic Filtering Systems for Electrical Power Application*, Max Rosenbäck and Frida Salehi, LTH.
30 Master's Thesis Presentation: *Auditory Attention Classification with Contrastive Learning*, Sofía Boselli and Gautam Sridhar, LTH.
31 Master's Thesis Presentation: *An ASR-based Hybrid Approach for Auditory Attention Decoding*, Alessandro Celoria and Valentín López, LTH.

June

03 Master's Thesis Presentation: *AI-driven Log Analysis for Intrusion Detection*, Linus Särud and Johan Sundin, LTH.
03 Master's Thesis Presentation: *Improving Temperature Estimation Models using Machine Learning Techniques*, Basim Elessawi and Van Duy Dang, LTH.
03 Master's Thesis Presentation: *Advanced Driver Assistance System (ADAS) for an Ultra Light Electric Vehicle*, Frida Lindbom and Jakob Petersson, LTH.
04 Master's Thesis Presentation: *Reinforcement learning for optimal control problems in continuous time and space*, Anton Forsell, LTH.
04 Master's Thesis Presentation: *Flexible Computer Vision based Sample Switching System using a Robotic Arm*, Anthon Andersson and Anton Håkansson, LTH.
05 Master's Thesis Presentation: *Robotised Guard Tours in Security Systems*, Johanna Häggström Wedding and Ella Thunborg, LTH.

05 Seminar: *Model-Free Analysis of Dynamical Systems Using Recurrent Sets*, Prof. Enrique Mallada, Johns Hopkins University.
05 Master's Thesis Presentation: *Detection and Tracking of Soil Microorganisms Using Deep Learning. Note: Location is "Maskrosen, at depertment of Biology, Ecology Building"*, Zuoyi Yu and Jingmo Bai, LTH.
07 Doctoral Thesis Defence*: Control Strategies for Physical Human-Robot Collaboration,* Salt Ducaju, Julian, LTH. Opponent: Professor Olav Egeland, NTNU.
07 Master's Thesis Presentation: *Deep hedging of CVA*, Oscar Gummesson Atroshi and Osman Sibai, LTH.
10 Seminar: *Wind farm modeling and control*, Dennice Gayme, Johns Hopkins Whiting School of Engineering.
11 Master's Thesis Presentation: *Design, Implementation and evaluation of a Fault Detection, Isolation, and Emergency Control Strategy for a Quadcopter System*, Björn Fredlund, LTH.
11 Master's Thesis Presentation: *Accelerated Segmentation with Mixed-Precision Quantization of EfficientViT-SAM*, Bernard Ryhede Bengtsson and Joel Bengs, LTH.
11 Master's Thesis Presentation: *Causal event processes and alarm analysis at ESS*, Vishnu Pradheep Raveendran, LTH.
11 Master's Thesis Presentation: *Graph Attention Network-Based Monitoring of Complex Operational Systems*, Stanislaw Swirsk and Ivar Källander, LTH.
11 Master's Thesis Presentation: *Robot Reinforcement Learning for Object Isolation*, Teodor Åstrand, LTH.
12 Master's Thesis Presentation: *Systemic Risk and Default Contagion in Financial Networks: Identifying Systemically Important Banks*, Ossian Relander and Oscar Clarke Nilsson, LTH.
12 Master's Thesis Presentation: *Embedded Model Predictive Control in ABB's Distributed Control System: A qpOASES-Based Approach*, Ludvig Hallabro and Jacob Rinderud, LTH.
13 Master's Thesis Presentation: *Exploring Multimodal Speech Processing: Neural Speech Tracking in EEG: Integrating Acoustics and Linguistics for Hearing Aid Users*, Klara Almgren and Annie Mentzer, LTH.
13 Master's Thesis Presentation: *Distributed Reinforcement Learning for Building Energy Optimization*, Arshad Javeed and Ewoud Donck, LTH.
13 Master's Thesis Presentation: *Physics-Informed Reinforcement Learning Feasibility Study for Building energy optimization*, Antoni Carrillo Sala, LTH.
13 Master's Thesis Presentation: *Automatic Robotic Dispensing and Cutting of Rubber Cable Into a Compression Molding Form*, Aslan Hamadi and Albin Magnusson, LTH.
17 Master's Thesis Presentation: *On the advantages of heterogeneity in bidirectional control of platoons*, Ask Hällström, LTH.
17 Master's Thesis Presentation: *Angular Velocity Estimation for Sensorless Brushless DC Motors*, Victor Martinsson, LTH.
20 Seminar: *Control of the Scanning Tunneling Microscope for Atomically Precise Lithography, Spectroscopy and Imaging*, Dr. Reza Moheimani, University of Texas at Dallas.

August
27 Seminar: *A Renaissance of Phase*, Prof. Li Qiu, Chinese University of Hong Kong.

September

10 Seminar: *The Douglas–Rachford algorithm for optimal control*, Bethany Caldwell University of South Australia.
18 Seminar: *Scheduling with Minimal Lag: borrowing from Combinatorics*, Associate Professor Enrico Bini, University of Turin.
19 Seminar: *On Graphs with Finite-Time Consensus*, César A. Uribe Rice University, USA.
20 Licentiate Defense: *Heuristic Methods and Opinion Dynamics* David Ohlin, LTH. Opponent: Assistant Professor César A. Uribe, Rice University, USA.
23 Seminar: *What is a Lise-Meitner Professor?*, Margret Bauer.

October

01 Master's Thesis Presentation: *Advanced Pulse Processing and Crosstalk Mitigation in X-ray Microcalorimeters Using AI and Hamiltonian Neural Networks,* Abdullah Shahin, LTH.
10 Seminar: *Distributionally Robust Control*, by Babak Hassibi, Caltech, USA.
10 Seminar: *Philosophies, promises and challenges of direct data-driven control*, by Valentina Bresch.
10 Seminar: *No such thing as a model-free lunch? Model-free search and reliable decision making*, Jack Umenberger, University of Oxford.
11 Doctoral Thesis Defence: *Minimax Adaptive Control and Estimation*, Olle Kjellqvist, LTH. Opponent: Senior Research Fellow, Dr. Jack Umenberger, University of Oxford.
15 Seminar: *Multiplicative Noise, Structured Stochastic Uncertainty, and Fragility in the Mammalian Cochlea*, Bassam Bamieh, University of California at Santa Barbara.
16 Master's Thesis Presentation: *Linear Programing and Robust Optimization of Electricity Resources on the Swedish Electricity Market*, Noah Åkesson, LTH.
24 Seminar: *Low-Complexity Worst-Case Load Flow for Power Distribution System Uncertainty Quantification - Solving Bilinear Programs Using Newton and Fixed-Point Iterations*, Kin Cheong Sou, National Sun Yat-sen University, Kaohsiung, Taiwan.
30 Master's Thesis Presentation: *Elasto-kinematic modelling and calibration of an industrial manipulator with a coupled wrist gearbox*, Teodor Westholm, LTH.

November

04 Master's Thesis Presentation: *Comparing performance of cyclic and event driven automation*, August Nyberg, LTH.
07 Seminar: *An introduction to microalgae production process: advantages, main dynamics and control challenges*, Malena Caparroz, University of Almeria.
19 Start of Robotics week for school classes.
20 Robotics Cognition and Automation - a robotics week seminar and lab tour.
21 Robotics Cognition and Automation - a robotics week seminar and lab tour.

December

11 Master's Thesis Presentation: *Chamber Pressure and Mixture Ratio Estimation and Control for a Staged Combustion Rocket Engine,* Elias Åberg Garcia, LTH.

External Engagement

External Engagement and events 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.

During the year we have arranged Conferences in Lund with international participation, the project "Female influencers in Automatic Control" has been highlighted at several international events and conferences, and the Robotics week is well visited from schools, companies and the general public.

21ST CONFERENCE ON ADVANCES IN CONTINUOUS OPTIMIZATION

The 21st EUROPT Conference on Advances in Continuous Optimization was organized by the Department of Automatic Control under the leadership of Pontus Giselsson. The event took place from June 26 to 28, 2024, and was preceded by an engaging summer school on June 24 and 25.

The summer school featured in-depth lectures by Gabriel Peyré on computational optimal transport and Gabriele Eichfelder on multiobjective optimization. With over 60 participants, these sessions laid a strong foundation for the main conference.

The conference itself showcased inspiring plenary talks by renowned speakers Gabriel Peyré, Amir Beck, and Sebastian Stich. Gabriele Eichfelder, honored as the 2024 EUROPT Fellow, delivered the EUROPT Fellow plenary lecture. With more than 200 enthusiastic attendees, EUROPT 2024 hosted six parallel sessions covering a wide range of topics in continuous optimization, including global optimization, multiobjective optimization, optimization for learning, first-order methods, monotone inclusions, and performance estimation.

A standout feature was the significant presence of young researchers at the PhD and postdoctoral levels, fostering an atmosphere of collaboration and curiosity. Their contributions greatly enriched the conference's dynamic and inclusive environment.

ELLIIT FOCUS PERIOD: SECURITY AND FAULT TOLERANCE OF CYBER-PHYSICAL SYSTEMS, LUND 2024

The ELLIIT Focus Period on *Security and Fault Tolerance of Cyber-Physical Systems* took place in Lund from April 1 to May 3, 2024. This focused initiative brought together an interdisciplinary group of leading international researchers, postdoctoral fellows, and graduate students to explore innovative solutions for designing robust, secure, and fault-tolerant architectures in cyber-physical systems. The event was part of ELLIIT's ongoing commitment to advancing cutting-edge research in information technology and its applications. The focus period addressed critical challenges in the development of cyber-physical systems, emphasizing the integration of security, safety, controllability, and dependability from the ground up. This was achieved through an ambitious program of activities designed to foster collaboration, encourage interdisciplinary dialogue, and catalyze innovative research.

Highlights of the Program

- Three-Day Symposium (April 16–18, 2024): A central highlight of the focus period was the three-day symposium that gathered prominent international researchers to present their work and engage in dynamic discussions. The symposium served as a platform for sharing insights on the latest developments, including techniques for ensuring reliability and resilience in increasingly complex cyber-physical systems.
- Seminars and Workshops: Throughout the focus period, a series of specialized seminars were conducted, featuring topics such as real-time system resilience, advanced control techniques, and cutting-edge cryptographic methods for securing interconnected devices.
- Specialized Course on Nonlinear Model Predictive Control: A comprehensive course on data-based and nonlinear model predictive control theory was offered, providing participants with an opportunity to deepen their understanding of this critical area. The course also facilitated knowledge exchange between visiting scholars and ELLIIT researchers.

The focus period was instrumental in fostering new collaborations and strengthening existing partnerships. Researchers from diverse backgrounds came together to tackle fundamental questions, propose novel methodologies, and lay the groundwork for future projects in secure and fault-tolerant system design. Participants lauded the program for its ability to stimulate innovative ideas and its success in creating an intellectually vibrant environment. The ELLIIT Focus Period not only advanced the state of knowledge in the field but also contributed to capacity building by providing a platform for early-career researchers to engage with leading experts. It reinforced the role of ELLIIT as a hub for cutting-edge research and innovation in cyber-physical systems, aligning with its broader mission to drive progress in information and communication technology.

By the end of the focus period, new professional connections had been established, and several promising research directions emerged, paving the way for advancements in making cyber-physical systems more resilient, reliable, and secure.

HISTORICAL FEMALE INFLUENCERS IN AUTOMATIC CONTROL

In 2024, the project "Historical Female Pioneers in Automatic Control" was highlighted at several prestigious international events and conferences. This initiative aims to honor and showcase the remarkable contributions of women in control engineering throughout the decades.

We now have agrowing collection of portraits and stories of these pioneering women, documenting their invaluable roles and highlighting their significance in the field. By doing so, we hope to inspire today's students and professionals, emphasizing the importance of female role models in control engineering.

Role models play a crucial part in shaping the future of the automatic control community. Experienced professionals influence the younger generation, guiding and inspiring them to pursue careers in this dynamic field. Historically, the field has been predominantly male, which is why many of the highlighted elder professionals are men. However, it is essential to also shine a light on the achievements of women, welcoming and encouraging a more diverse workforce.

Diversity and inclusion are vital for the continued success and innovation in automatic control. By celebrating female pioneers, we aim to foster a sense of belonging and inspire future generations to contribute to this exciting field.

Throughout 2024, our project was showcased at various international conferences, both through presentations and exhibitions:

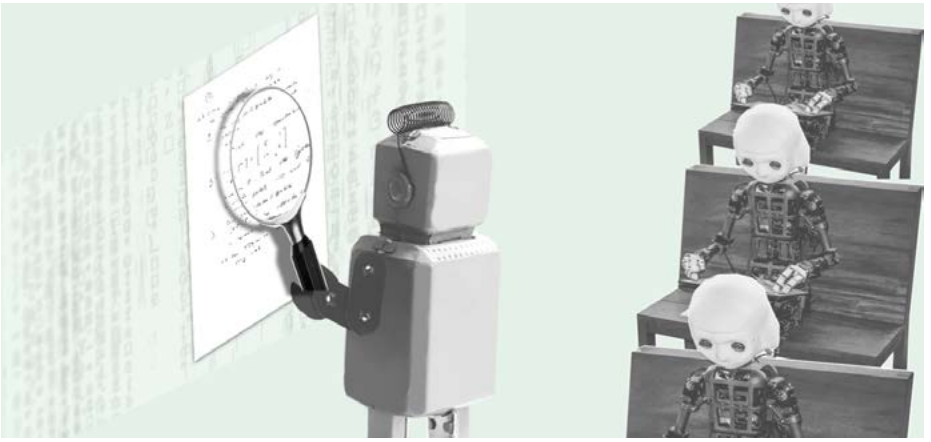
ELLIIT 2024 – March 8, Lund, Sweden.
IFAC PID 2024 – June 12-14, Almeria, Spain.
ECC 2024 – June 25-28, Stockholm, Sweden.
Reglerteknik 75 år i Sverige – June 29, Stockholm, Sweden.
CCA 2024 – September 17-20, Mauritius.
CDC 2024 – December 16-19, Milano, Italy.

AI LUND

AI Lund is an open network for research, education and innovation in the domain of artificial intelligence at Lund university.

Many researchers at the Department of Automatic Control actively contribute to the network. In 2024, they have been involved in three lunch seminars, AI Nordic Powwow in May and Robotics Week in November. The department's TA staff also participate in organizing AI Lund as such as by administrating parts of AI Lund's finances.

The EU Robotics Week is now well established and engage many of us during a week in November, with presentations and demos for visiting schools, companies, and the general public.



EUROPEAN CONTROL CONFERENCE AND 75 YEAR CELEBRATION IN STOCKHOLM

European Control Conference 2024 was organized in Stockholm, June 25-28, 2024. This is the main European conference in the field and this was the first time it was held in Sweden. Several members of the department were heavily involved in the organization, Anders Rantzer as General co-chair, Emma Tegling as Publicity co-chair and Charlotta Johnsson as Industry Co-chair. Moreover, Luka Bakovic, Alba Gurpegu, Ahmed Albayati Talitha Nauta, Olle Kjellqvist, Max Nyberg Carlsson, Julia Adlercreutz, Yde Sinnema, Zheng Jia, Fethi Bencherki and Emil Sundstrom served as volunteers during the event.

The conference was a big success with 1 100 registered participants, more than ever before, from all over the world (Sweden 213 participants, Germany 147, USA 82, Italy 77, France 66, Netherlands 61, China 55, United Kingdom 48, Switzerland 47, Japan 31, etc.)

On June 29, a smaller event was organized to celebrate 75 years since the first Swedish University course in control engineering. Members of all major universities presented their view of the subject history in Sweden and its industrial impact.

Economy

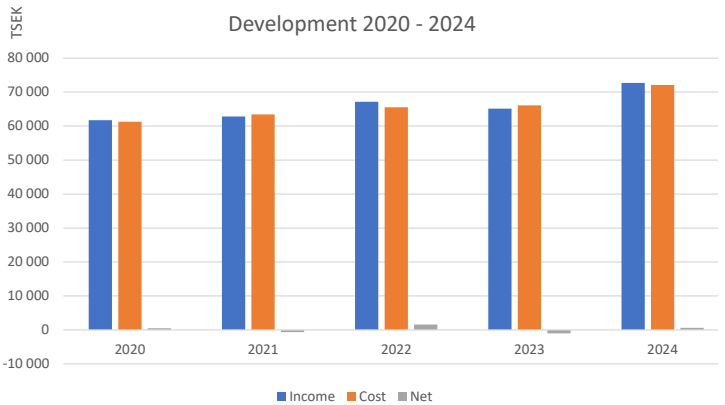
This chapter contains an overall view of the economy and funding

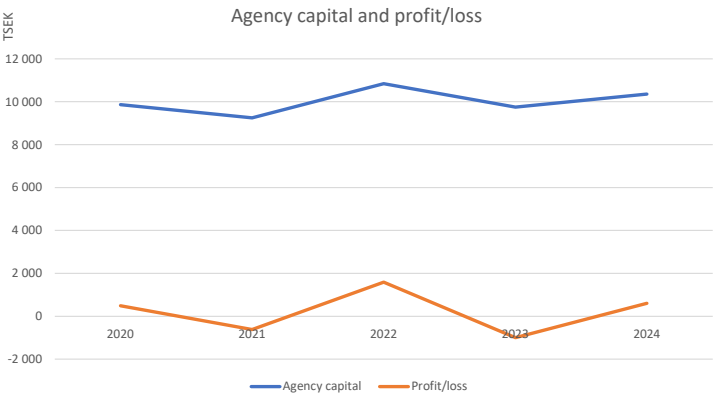
ECONOMY

The turnover for 2024 was 72,8 MSEK, an increase of 7,7 MSEK compared to 2023. About half of the income comes from Lund University and the remaining half from external grants. We made a positive result of 0,6 MSEK and have an Agency capital of 10,3 MSEK.

Today the number of employees are 59 people. The number of employees corresponds to 51 full-time equivalents. Substantial support of our different activities have been provided by the European Union Horizon 2020 programme, Knut and Alice Wallenberg Foundation (KAW) and ELLIIT where and we have been successful in receiving funding for both new PhD and Postdoc positions. We also receive funding from Swedish Research Council (VR), and Swedish Government Agency for Innovation Systems (Vinnova).

The block grants from 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.





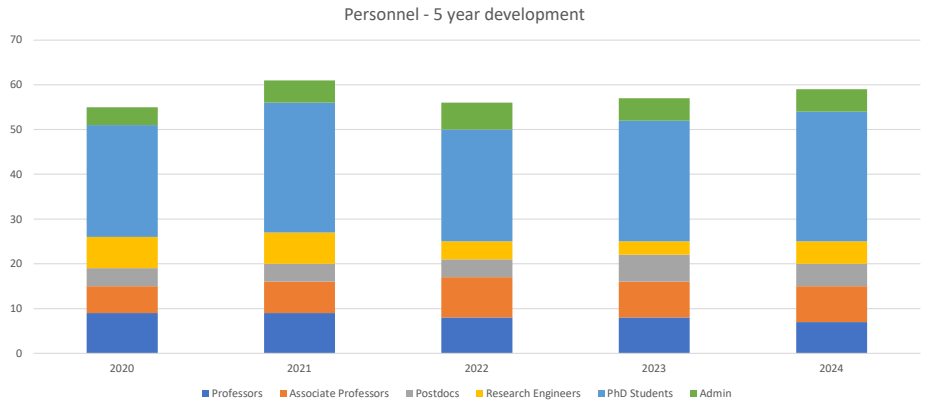
FUNDING

During 2024 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
VR – Research collaboration Italy-Sweden
Vinnova – Advanced Offloading for Real-Time Applications (AORTA)
Vinnova – Advanced Driver-Assistance System for Micro mobility Vehicles
EU Horizon 2020 – Scalable Control of Interconnected Systems - an ERC project
KAW – Wallenberg AI, Autonomous Systems and Software Program (WASP)
KAW – WASP DDLS/Twinning of Postdocs
KAW – WASP PhD NEST
KAW – WASP Postdoc NEST
KAW – WASP NEST Cyber Security
KAW – WASP WARA-PS
KAW – WASP WARA-Robotics
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
ELLIIT – Gender
NordForsk – Nordic University Hub on Industrial Internet of Things (HI2OT)
Mats Paulsson Foundation - Functional ex vivo heart evaluation
IFAC Activity Fund
IEEE-CS-Activity Fund
The Hjelm Family Foundation - Functional ex vivo heart evaluation
Crafoord Foundation. Project: 2DCAM
SARS (Scholars At Risk Sweden), Co-funding 2DCAM
SSF – Conference and information funding

Staff

In this chapter the staff and their activities are described


Personnel - 5 year development
70
60
50
40
30
20
10
0
2020
2021
2022
2023
2024
Professors
Associate Professors
Postdocs
Research Engineers
PhD Students
Admin

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

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

Associate Professors
Cervin, Anton (on leave 2024)
Como, Giacomo (25%)
Giselsson, Pontus, director of graduate studies
Karayiannidis, Yiannis
Olofsson, Björn (70%), director of undergraduate studies
Pates, Richard
Soltesz, Kristian
Tegling, Emma; deputy head of department

Research Engineers
Blomdell, Anders
Nilsson, Anders
Pisarevskiy, Alexander
Stenberg, Oskar (20%) (from September)

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

Postdocs
Jeeninga, Mark
Sundell, Jesper
Ziemann, Ingvar
Renganathan, Venkatraman (until August)
Wu, Dongjun

Researcher
Voitenko, Volodymyr

PhD Students
Adlercreutz, Julia
Agner, Felix
Al-Bayati, Ahmed
Åkerman, Anton
Bakovic, Luka
Bencherki, Fethi
Fregnan, Sebastiano (from January)
Gemborn Nilsson, Martin
Grönqvist, Johan
Guberina, Marko
Gurpegui Ramón, Alba
Hällström, Ask (from August)
Hansson, Jonas
Heskebeck, Frida
Jia, Zheng
Kjellqvist, Olle
Laban, Lara (until October)
Lindberg, Johan
Nauta, Talitha
Nilsson, Max
Nyberg Carlsson, Max
Ohlin, David
Pigot, Henry (until March)
Salt Ducaju, Julian (until June)
Sinnema, Yde
Sundström, Emil
Upadhyaya, Manu
Vladu, Emil
Wahlquist, Ylva

Industrial PhD Students
Norlund, Frida; Boliden AB
Mathai, George; Ericsson AB
Stoltenberg, Peter; Saab Kockums AB
Tufvesson, Pex; Ericsson AB
Wingqvist, Birgitta; Saab Kockums AB

LISE-MEITNER-PROFESSORSHIP 2021-2024 - PERSONAL STATEMENT BY MARGRET BAUER

It has been a great honour and privilege to act as the Lise-Meitner-professor from the period of 2021 to 2024 at the Department of Automatic Control at Lund University. I was employed as a 20% part-time professor during this time while working full-time as a professor in process automation at the University of Applied Sciences in Hamburg.

As part of the appointment, Charlotta Johnsson, Eva Westin and myself with other colleagues in the department started the *Historical Female Influencers in Automatic Control*: A collection of biographies of women who dedicated their lives to control engineering and who serve as a role model for women engineers now and in the future. The initiative received funding from the International Federation of Automatic Control (IFAC), the IEEE Control Systems Society and the national ELLIIT funding body.

Showcasing role models in control is the idea behind the Lise-Meitner-Professorship and working on the portraits of important women in control has arguably been the most important work. The most fun, of course, was working with the colleagues at the department and with the incredibly bright PhD students. In particular Frida Heskebeck on designing a workplace equality workshop for Master's students, co-supervising Frida Norlund's PhD working on a minerals processing plant and discussing PID control with Emil Sundström while getting to know other students during fika and departmental meetings and presentations.

The attractiveness of the Lise-Meitner-professorship is bolstered by the fact that there are very few rules and guidelines. It allowed to make this work during the COVID-pandemic where we could meet online due to travel restrictions between Germany and Sweden. It was a joy to visit in person after the restrictions had lifted, initially for a period of two weeks and then for weekly visits whenever my teaching obligations in Hamburg allowed me to come.

Because there are no formal project deliverables – no PhD thesis, no publications, no project milestones – it was possible to really think out of the box and simply do work that we believed was important. As a result, I believe this has been the most prolific time of my academic career, with not necessarily classic but important outcomes: Filming videos with Karl Johan Åström and Charlotta Johnsson, translating Tore Hägglund's book on process control from Swedish to English, creating

drawings of control engineering topics with an online presence of several hundred thousand views and working on a standard implementation of the good, old PID controller.

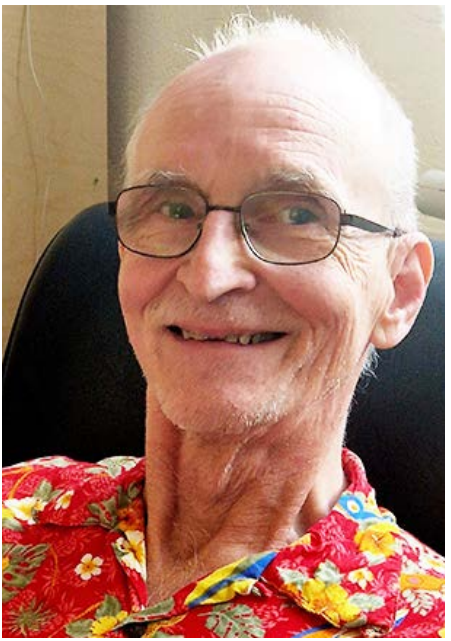
The outcomes of the professorship are visibility of women in the community and refocusing the research direction on topics that are not mainstream but nevertheless highly important. It is currently easy to attract funding when working on anything with digitalization and artificial intelligence, but the focus does not address or solve today's problems: mitigating climate change, reacting well to a pandemic or political instability. Publications were more of a side product – four conference papers and three journal publications.

The three years were thrilling and stimulating. Despite doing this on top of my full-time appointment in Hamburg, I felt that this was most productive. Taking breaks between visits can grow research because it leaves time to think about the questions and directions while you are away. I hope that this will become a standard format and I am most pleased that there will be a new Lise-Meitner-Professor starting soon.

ANDERS BLOMDELL AWARDED FOR HIS EXCELLENT WORK OVER THE YEARS

Anders Blomdell, research engineer at the department, has been awarded the Royal Physiographic Society in Lund award to technical staff 2024. Anders has been working at the department since 1988 and he has over the years been instrumental in the development of the excellent computer and server system, course laboratory, and experimental research infrastructure (including RobotLab LTH). Through innovative, smart, and cost-efficient solutions, Anders has made it possible to maintain the extensive experimental activities at the department over the years, both in research projects and in courses given as part of the undergraduate education. He has also made substantial contributions to several research projects and in the preparations of demonstrators in EU projects.

The department is very proud of you Anders, and with your extensive experience and competence we look forward to your continued contributions to the research and teaching at the department!



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


Richard


Frida


Johan


Yiannis


Cecilia


Emil

Jälm@regler is the dedicated gender equality, equal opportunities, and diversity group at our department. Since its start in 2014, the group has been actively working to create an inclusive and supportive environment. The group have organized seminars and workshops featuring invited speakers who address a wide range of topics, including research, ergonomics, security, and implementation. These events create valuable opportunities for discussion and learning, helping to raise awareness and drive positive change.

Key Activities in 2024

In 2024, the group, consisting of Richard Pates, Frida Norlund, Johan Lindberg, Yiannis Karayiannidis, Cecilia Edelborg and Emil Sundström, has been involved in several activities:

- Seminars and Workshops: Continuing the tradition of inviting experts to speak on various topics, these events have provided insights and fostered discussions on gender equality and diversity.
- Coffee Break Discussions: Creating informal spaces for conversations about gender equality and diversity has proven crucial for fostering awareness and encouraging positive change within the department.

Inspiring Project: Historical Female Influencers in Automatic Control
One of the standout initiatives is the project titled "Historical Female Influencers in Automatic Control". This project highlights the contributions of female pioneers and role models in the field of control technology. By celebrating their achievements, the project aims to inspire current students and shape the narrative for future generations. The stories of these women serve as powerful reminders of the significant impact women have had and continue to have in technology and academia. The project has been presented both at European Control Conference in Stockholm 2024 and Control Conference Africa in Mauritius 2024 and at different events in Lund.

Notable Contributors for Historical Female Influencers in Automatic Control:

- Charlotta Johnsson, Professor
- Kristian Soltesz, Associate Professor
- Tore Hägglund, Professor Emeritus
- Eva Westin, Administrative Manager
- Margret Bauer, Lise Meitner Professor

ALUMNI GATHERING AT THE DEPARTMENT

It had been a while since we last hosted an alumni gathering at the Automatic Control Department in Lund. But after both the pandemic and our move back to the M-building, we finally made it happen!

On Friday, October 4, we welcomed our alumni to a Friday seminar where we presented the latest developments at the department, followed by a tour of our facilities and the RobotLab. After the presentation and tour, we continued to the kitchen and the adjacent penthouse for some snacks, drinks, and socializing.

We were delighted to see so many of our alumni, both from near and far, and it was the perfect way to kick off the weekend! While we don't have a fixed schedule for alumni events, they will certainly continue—so keep an eye out for the next invitation!

LONG-TERM VISITORS

Fantozzi, Italo, PhD student, University of Rome Tor Vergata, Italy (March–June)
Zhu, Shiyong, PhD student, City University of Hong Kong, Hong Kong (February–April)
Bamieh, Bassam, professor, University of California at Santa Barbara, USA (September–October)
Baum, Taylor, PhD student, Massachusetts Institute of Technology, USA (March–April)
Carriero, Graziano, PhD student, Università degli studi della Basilicata, Italy (from October)
Caparroz, Malena, PhD student, University of Almería, Spain (November)

BOARD OF THE DEPARTMENT

Anders Rantzer
Karl-Erik Årzén
Charlotta Johnsson
Martina Maggio
Kristian Soltesz
Björn Olofsson
Yiannis Karayiannidis
Richard Pates
Mark Jeeninga
Monika Rasmusson
Anders Nilsson
Talitha Nauta
David Ohlin

ACTIVITIES OF STAFF

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 the application of district heating systems. The focus is to design control systems of all of the multitude buildings connected to the network in a smart way. In particular, to understand how simple control schemes can be used for load balancing purposes. This means that when the available capacity to deliver heat to the consumers is not enough, the heat should be distributed in a fair fashion. In January 2025 he will defend his thesis *Control of Capacity Constrained Networks - in a District Heating Setting*.

During the year he has supervised labs in our course *Learning Based Control*.

He has also, together with PhD student Julia Adlercreutz and previous PhD Harry Pigot, investigated the impact that new large language models (like Chat-GPT) can have on department teaching. We conducted an experiment to see if students with no automatic control background could pass our basic course exam with these tools. We talked about this study at an AI-lund seminar as well as a teaching conference in Copenhagen.

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 *automatic control basic course* and the advanced courses in *mathematical modelling* and *automatic control*.

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

Current research is on first order splitting methods for solving monotone inclusion problems.

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

Al-Bayati, Ahmed
MSc in Engineering Physics from LTH (2024), and has been a PhD student since August 2023.

His research focused on offloading control algorithms to the cloud and/or edge under the supervision of Professor Karl-Erik Årzén. Ahmed is funded by the AORTA project.

In 2024, Ahmed worked on developing a motion planning algorithm designed for edge deployment. This planner efficiently avoided obstacles while generating trajectories that respects jerk constraints.

In addition to his research, Ahmed taught *Real-Time Systems* in the spring and the *Basic Control course* in the winter.

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. PhD student at the department since 2022.

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

This year, he was on a four month visit to the Department of Mathematical Sciences at Politecnico di Torino.

He has been involved in teaching the *Learning-Based Control course*.

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

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 part of the WASP-NEST project and his research focuses on developing scalable control approaches for large-scale networks. His interests also include learning-based control and the identification of switched systems.

In 2024, his teaching assignments included the *Automatic Control Basic 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 international masters program in *Machine Learning, Systems and Control*.

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

Bo's main current research interest is in control and statistical learning with applications on for example EEG signals, communication systems and data from life sciences.

He is the main supervisor of 4 PhD students within this area and co-supervisor of 4 other PhD students. He is also responsible for the coordination of our Master Thesis projects.

During 2024 he taught the basic control course at two occasions. Together with colleagues at KTH and LiU he also held the WASP PhD course in *Autonomous Systems.* He also supervised 9 Master's Theses projects and was the examiner on 7 projects.

During one week in March he participated in the 3rd Insights Lab Research Camp a multidisciplinary event, organized by Institut Roche,that brings together researchers with diverse specialties and backgrounds (medicine, biology, mathematics, physics and chemistry) to address exceptional challenges in the life sciences and health sciences. The main objectives of these events are to promote collaboration between experts and to boost innovation in solving critical problems in biomedicine.

In May he participated in a meeting in Gothenburg between 14 academic and government experts from Sweden, Norway, Denmark, and USA with the task to propose guidelines for modeling infectious diseases, with a focus on models that serve as the basis for decision-making. The guidelines will be published in *Handbook of Mathematical Modeling of Infectious Diseases for Descion-Making* [Geerle et al 2025].

Blomdell, Anders

Research Engineer at the department since 1988.

Responsible for the department network and lab computers for teaching and research.

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 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 2024, he has served as co-supervisor of Luka Bakovic at Lund University and as supervisor of Sebastiano Messina, Alexia Ambrogio, Davide Sipione, and Leonardo Cianfanelli and co-supervisor of Martina Alutto, and Roberta Raineri at Politecnico di Torino.

In Spring 2024, he taught the master level course *Network Dynamics* and the PhD course *Game Theory* at Lund University.

During 2024, 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 University in 1999 and became full Professor in 2023.

His research interests includes methods and programming languagees for parallel systems, real-time control systems, data-driven operation and cloud computing technologies. His current research focus is on compute offloading and data-driven operations of large scale systems. 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 WARA-Ops.

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

Fregnan, Sebastiano
MSc in Computer Engineering for Robotics, 2022. He has been a Research Fellow at University of Verona before joining the department as PhD student at the beginning of 2024.

His research focuses on whole-body compliant manipulation and aims to render robotic motion feel more natural while dealing with spatial obstacles and achieving tasks requiring exploration of and contact with the environment. In particular, he is using an ABB YuMi robot equipped with custom mounted force/torque sensors, which will be mounted on the "Sleipner" mobile platform robot. He is also affiliated with WARA Robotics and participated to the Mobile Manipulation Challenge at ABB Corporate Research Center.

His teaching activities consisted of lab supervision of the *Automatic Control, Basic Course* and project supervision of two groups for the *Mathematical Modelling Course.*

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 focuses on the representation, visualization, and classification of multivariate time-series using covariance matrices, with the primary application being improved efficiency of EEG-based Brain-Computer Interfaces.

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

Giselsson, Pontus
Pontus has been serving as an Associate Professor in the Department of Automatic Control since 2017. He completed his PhD at the Department of Automatic Control in 2012. Pontus was awarded the title of Reader (Docent) in 2018.

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

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 his 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.

Guberina, Marko
MSc in Physics Engineering 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.

This year he focused on the WARA mobile challenge participation, resulting in a paper submission.

Gurpegui Ramón, Alba
MSc in Mathematics, Lund University. PhD Student at the department of Automatic Control since August 2022, supervised by Anders Rantzer.

Her main research interests include optimal and robust control of positive systems, and their applications to large-scale systems and network synchronization. She is part of the NEST project Learning in Networks.

In 2024, her teaching responsibilities included the following courses; *Advanced Control* and *Basic Control.* She has also been the Master's Thesis supervisor for Lukas Christensson and Martin Lindell.

She participated in ACC Toronto in a regular session as co-chair and presented her work *Minimax Linear Optimal Control of Positive Systems*. She also presented her extended abstract *Minimax Optimal Control with linear cost* in a regular session of the 26th International Symposium MTNS. Alba volunteered at the European control conference, helping with the organisation.

Hällström, Ask
MSc in Engineering Physics, LTH (2024). PhD student since August 2024.

This year, he has worked on generalizing the results from his Master's Thesis, which focused on the use of heterogeneity in the control of platoons. Additionally, he has begun collaborating with the Division of Industrial Electrical Engineering and Automation (IEA) on research into the reuse and control of old electric vehicle batteries for grid applications. He is supervised by Richard Pates and funded by Compel.

During the year, he has also served as a teaching assistant for the course on *Non-Linear Control and Servo Systems*.

Hansson, Jonas
Licentiate Jonas Hansson is a fifth-year PhD candidate at the Department of Automatic Control, Lund University, supervised by Emma Tegling and Anders Rantzer, with funding from WASP.

His research focuses on the control of network systems with locality constraints, emphasizing scalable and robust control design with transient performance guarantees. He is also interested in system identification, contraction theory, and fundamental control limitations.

During the year, Jonas contributed to teaching as a teaching assistant in the *Advanced Control Course*. In November he visited UCLouvain, Belgium, to engage with the research group of Prof. Julien Hendrickx.

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.

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, funded mainly by WASP.

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

Mark hosted Thijs van Oorschot, a master student from Eindhoven University of Technology,

in spring 2024. Thijs produced a research paper that was presented at the Robotics conference in Delft, The Netherlands, and has been submitted to the ECC 2025.

In May 2024, Mark approached LU Innovation with a business idea revolving around the computational tasks of grid operators. His idea was selected for the LU Business Track program. In September 2024, his project was awarded a spot in the 2024 SPiRiT Programme–an intense 8 week programme centered around customer discovery and entepreneurial development. Mark's position has been funded for 80% by LU Innovation throughout the duration of the SPiRiT Programme.

He is supervising the master students Louise Nyberg and Samuel Golobov.

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). Charlotta is the Dean of Campus Helsingborg, Lund University. She is also the deputy director for the makerspace X-Lab at LTH, an open innovation space for both students and colleagues.

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.

During the year 2024, 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. Charlotta has also given invited seminars to industry focusing on Industry 4.0/ Smart Manufacturing.

During the year Charlotta welcomed the guest Italo Cesidio Fantuzzi for a visiting period of 3 month.

Karayiannidis, Yiannis

He is Associate Professor at the Department of Automatic Control since 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, contact modeling for manipulation, bimanual and mobile manipulation, manipulation of deformable objects, and dynamic trajectory generation for robotic systems under constraints.

During 2024, Yiannis was responsible for the undergraduate level courses in *Nonlinear Control and Servo Systems* and *Mathematical Modeling*.

He supervised two master projects and two PhD students working on hand-arm coordination and mobile manipulation respectively, 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 (of which two graduated in 2024).

Kjellqvist, Olle
MSc in Engineering Physics from Lund University in 2018. Olle received his Licentiate degree in automatic control in 2022 and defended his Thesis *Minimax Adaptive Control and Estimation* in October.

Olle was 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 taught the PhD level course *Control System Synthesis*, supervised two Master's Theses, and spoke at ECC in Stockholm and L4DC in Oxford.

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 2024 Johan supervised a Master 's Thesis for Noah Åkesson titled *Optimization of Electricity Resources on the Swedish Electricity Market*. He was also a teaching assistant in the bachelor courses *Control Theory* and *Automatic Control, Basic Course.*

Maggio, Martina
PhD, Politecnico di Milano in 2012, focusing on applying control theory to computing systems, and joined Lund University right after for her postdoc and then for an assistant professorship (2015) and associate professorship (2017).

Martina is Professor at the Computer Science Department, Saarland University since March 2020 and part time at the Department of Automatic Control, Lund University since 2023.

Her research focuses on secure autonomy, and trustworthy cyber-physical systems.

In 2024, at Lund University, she led two WASP NEST projects: *Intelligent Cloud Robotics for Real-Time Manipulation at Scale* and *Dynamic Attack Detection and Mitigation for Secure Autonomy*. She also led the VR Italy-Sweden collaboration project, *Trustworthy Cyber-Physical Pipelines*.

Martina taught the master's course *Real-Time Systems* and supervised PhD students Yde Sinnema and Talitha Nauta at Lund University, as well as Melanie Gallant at Bosch GmbH through Saarland University.

Nauta, Talitha
MSc in Engineering Mathematics from Lund University in 2023. She has been a PhD student at the deparment since September 2023, under the supervision of Martina Maggio.

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

In 2024 she has been a teaching assistant in *Mathematical Modeling*, *Project in System, Control and Learning*, and *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. He is a PhD student since January 2022.

Max research interests are in first order splitting methods and non-Euclidean optimization.

During 2024 year Max has been a TA for *Optimization for Learning* and for *Automatic Control, Basic Course*. He has been leading the PhD-course *Pragmatic Programming* and been responsible for the Friday seminar schedule. He has also supervised a project in *Project in*

Systems, Control and Learning and was a co-supervisor for thesis project titled *Optimization of Electricity Resources on the Swedish Electricity Market*. Max was part of organising the conference EUROPT 2024.

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.

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

During 2024, focus was on sampling faster than the control software computational delay. He also volunteered at the conference ECC2024 in Stockholm.

Teaching duties during 2024 were *Real-Time Systems* in the spring and the project course in the fall.

Ohlin, David
MSc Engineering Physics (2021), LTH. David defended his Licentiate Thesis *Positive Network Systems: Heuristic Methods and Opinion Dynamics* in September 2024. PhD student since 2021, supervised by Emma Tegling and Anders Rantzer. He is part of the WASP NEST project *Learning in Networks: Structure, Dynamics, and Control.* He represents the PhD students on the department board as one of two elected representatives.

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 2024 were comprised of two masters-level courses: course development of *Learning-Based Control* and teaching assistance in *Network Dynamics*.

Olofsson, Björn
He obtained his PhD in Automatic Control in 2015, 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 courses *Applied Robotics* and *Applied Robotics for Architects* 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 three PhD students and co-supervisor of two PhD students at the department. He is in addition co-supervisor of one PhD student at Dept. Computer Science, one PhD student at Dept. Architecture and Built Environment, and two PhD students at Div. Vehicular Systems, Linköping University.

Pates, Richard
Richard received his PhD degree in 2014, 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 three PhD students and an assistant supervisor for a further three. In addition, in the academic year 2023-2024 he supervised six master's thesis students, taught the *Control Theory Course*, and also taught the *Advanced Control Course*.

Pigot, Henry
Henry's main interest is medical technology development.

In March he defended his thesis named *Afterload system design for functional donor heart assessment*.

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

Alexander mainly participates in upgrading of lab equipment for education processes and research work.

In 2024 he took part in a project dedicated to human–robot interaction and in a few student projects.

Rantzer, Anders
Professor of Automatic Control since 1999. 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 2024, he taught the masters level courses *Learning-based Control* and *Modeling and Learning from Data*.

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.

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

In June, he defended his thesis *Human-Robot Collaboration for Kinesthetic Teaching*.

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 that year.

During 2024, his research has been focused on the analysis of real-time control systems under sensor timing misalignments, in collaboration with his main supervisor Martina Maggio.

He was involved as a teaching assistant in the courses *Real-time Systems* and *Modelling and Learning from Data*.

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. He also serves as director of the Engineering Physics program in Lund.

His main research interest is data-driven modeling and control of cyber-physiological systems.

His research projects during 2024 involved technological methodology development for

improved heart transplantations, data-driven methods for sustainable minig of minerals, and novel methodologies for individualized pharmacological modeling.

During the year he was the main advisor of doctoral students Henry Pigot (graduated 2024), Ylva Wahlquist, and Frida Norlund, and of postdoc Jesper Sundell. He was also involved as co-supervisor with doctoral students Emil Sundström and Martin Gemborn Nilsson.

He was teaching a course in *Physiological Modeling.*

Stenberg, Oskar
Research Engineer at the department since September 2024, at present on part time as it is his last year of studies for a MSc in Computer Science.

Currently, he is working on further developing digital twins of our computer environment to enable testing changes before they affect the rest of the department. He is also developing new versions of hardware for course labs, and has guided summer workers in 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 focus is on control systems strategies for autonomous vehicles, specifically how cloud computing and offloading can improve performance of computationally heavy control algorithms.

Tegling, Emma
PhD in Electrical Engineering from KTH Royal Institute of Technology, Sweden, 2019. Emma is Senior Lecturer (associate professor) since 2021 and Deputy Head of Department since 2024.

Emma'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 involved in the interdisciplinary initiative called the *N-body society* with mathematicians and social scientists, investigating challenges to democracy.

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

During 2024, Emma was on the organizing committee of the European Control Conference, and was elected to the IEEE Control System Society's Board of Governorns.

She was on parental leave for the second half of 2024.

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 synthesizers.

He has founded startups doing 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 and MSc in finance, 2020, Lund University. He is a PhD student since July 2020.

His research focuses on continuous optimization and its applications in machine learning, control, and finance, with an emphasis on designing and analyzing first-order methods for convex optimization and monotone inclusion problems.

In 2024, Manu served as a teaching assistant for *Optimization for Learning*. He also co-supervised a Master Thesis titled *Deep Hedging of CVA,* completed by Oscar Gummesson Atroshi and Osman Sibai in collaboration with Nordea Markets. The project was co-supervised by Magnus Wiktorsson (Lund University) and Shengyao Zhu (Nordea Markets).

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 performance analysis of dynamical systems with conic constraints, and applications include large-scale systems.

Being in the final year of his PhD studies, he has had no teaching responsibilities. Instead, focus has been on outputting multiple papers and writing his thesis.

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, Associate Professor on the Department of Electronics, Automation, Robotics and Mechatronics at the Chernihiv Polytechnic National University (Ukraine) and Honorary Professor of the same University in Chernihiv.

He is the Principal Investigator in the project *Subsystem for two-coordinate positioning of the UAV auxiliary video camera (2DCAM).*

During the year he has had teaching assignments in the following courses at Chernihiv Polytechnic National University: *Digital Image Processing*, *Display systems* and *Industrial Controllers* Volodymyr has also been supervisor for PhD student Maksym Solodchuk during the year.

Crafoord Foundation and SARS (Scholars at Risk Sweden) made it possible to extend his stay in Sweden and at the department. SARS is a network for protecting academic freedom which enables asylum for researchers at a university outside their native country.

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

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

During the spring of 2024, Ylva visited Prof. Antonio Visioli's research group at the University of Brescia, Italy.

During the year, Ylva has been a teaching assistant for the *Physiological Models and Computation* course and the *Process Control & Systems Engineering* course.

Westin, Eva
PhD in French linguistics. Administrator at Automatic Control since 2008 and administrative manager from 2017 for the administrators and research engineers at the department.

She handles the overall responsibility of human resources, guests and conferences. She also handles part of the process for research studies.

Eva is part of the steering group for AI Lund. She is also a member of the LTH Board.

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 and funded by the ERC project Scalable Control of Large Scale Systems under the supervision of Prof Anders Rantzer. He got a double PhD degree from Université Paris-Saclay CNRS-L2S (Automatique) and Harbin Institute of Technology (Control science and engineering), March 2022.

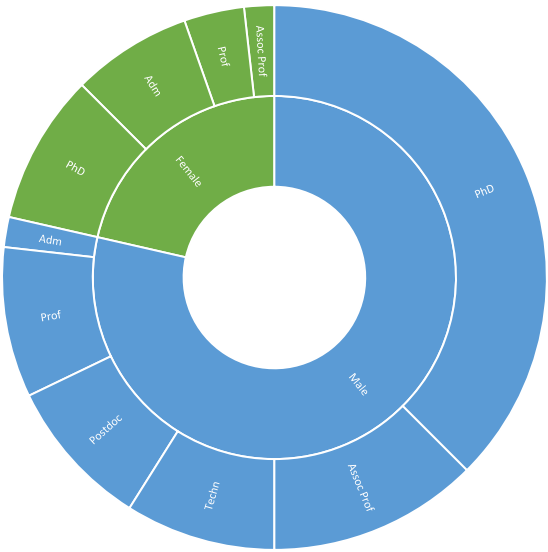
His research focuses on large scale systems, optimal transport and nonlinear control. In particular, he is interested in applying control theory and tools to solve dynamical optimal transport problems.

This year, he has been co-supervising PhD candidate Emil Vladu with Anders Rantzer, and Master student Guilherme Junqueira Perticarari together with Professor Thierry Baasch from Department of Biomedical Engineering, LTH.

Dongjun has attended two conferences this year; ECC in Stockholm, and CDC in Milan.

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.



Allocation between male and female at the Department as well as divided per category, in total 59 employees.

AWARDS

GRANTS

Travel grant from the Royal Physiographic Society

Ylva Wahlquist received a travel grant from Royal Physiographic Society for a visit to Prof. Juan Albino Méndez Pérez's group at the University of La Laguna, Tenerife, in October.

Dongjun Wu received a travel Grant from Royal Physiographic Society Travel Grant for Young Researchers.

Manu Upadhyaya received a travel grant from Royal Physiographic Society for a workshop on Nonsmooth Optimization and Applications (NOPTA 2024) in April, at University of Antwerp.

Royal Physiographic Society award

Anders Blomdell was awarded the Royal Physiographic Society in Lund award to technical staff in 2024.

Certificate of Gratitude

Volodymyr Voitenko was awarded a Certificate of Gratitude for Conscientious Work as part of the Sectoral Competition Commission of the All-Ukrainian Competition of Student Scientific Works in the Specialty "Electronics".

WASP Research Stint Grant

During spring Jonas Hansson was awarded funding for a three-month research visit at UC Santa Barbara.

Manu Upadhyaya was awarded funding for a six-month stay in Paris collaborating with the Sierra team at Inria Paris, hosted by Francis Bach and Adrien Taylor, to further his work on advanced optimization methods.

David Ohlin was awarded funding as a visiting scholar at UC Berkeley with the research group led by Murat Arcak.

Travel grant from the Walter Gyllenberg Foundation

Dongjun Wu received a travel grant from The Fund of the Walter Gyllenberg Foundation.

Certificate of Outstanding Service as Reviewer

Mark Jeeninga has been awarded the *Certificate of Outstanding Service as Reviewer of the IEEE Control Systems Letters - 2024* for his outstanding contributions as a reviewer to the L-CSS journal.

Young Author Award

Frida Norlund received the Young Author Award at the 4th IFAC Conference on Advances in Proportional-Integral-Derivative Control for her contribution in the article *Seamless PID–MPC Hybrid Control.*

Frida Norlund

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 the Strategic Advisory Board for the Department of Electrical Engineering, Aalto University.
Member of the Scientific Advisory Board of SMaRC, Swedish Maritime Robotics Center.
Chair of the Department board.
Chair of the board for the LTH RobotLab.

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.
Board member of Campus Vänner, Helsingborg, Sweden.
Board member at Helsingborg Innovations District, Helsingborg, Sweden.
Board member of Haakon Hanssons Stiftelse.
Chair of the Board for IIIEE (International Institute for Industrial Environmental Economics) at Lund University, Sweden.
Board member of X-Lab, Lund University.
Board member of Campus Helsingborg, Lund University.

Rantzer, Anders
One of two co-directors for the ELLIIT focus period program.
Vice Chairman for the Royal Physiographic Society of Lund.
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.

Tegling, Emma
Member of the Board of Governors, IEEE Control Systems Society.
Member of the Coordinator Board for the LTH Focus Area Pillars of AI and Digitalization.

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 Artificial 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.

Johnsson, Charlotta
Member in the European Control Conference Committee 2024, focus on Industry Day.
Member in the IFAC Activity Fund Committee, focus on IFAC's outreach activities.

Pates, Richard
Member of the Control System Society Technical Committee on Power Generation.

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

Soltesz, Kristian
IFAC Advances in Proportional-Integral-Derivative Control.
FAC Internet-based Control Education.

Tegling, Emma
Publicity Chair for the European Control Conference 2024 in Stockholm.
Diversity and Inclusions Chair for the upcoming IEEE Conference on Decision and Control 2026.
Member of the International Program Committee for the 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 Pedro Roque, KTH, October 8.

Bernhardsson, Bo
Substitute member of the PhD examination committee for Mattias Karlsson at the department of biomedical engineering, LTH.

Eker, Johan
Member of PhD thesis committee at Mälardalen University, in October.
External evaluator for endowed Professorship for Edge AI at University of Innsbruck, in June.
Member of PhD thesis committee at Royal Institute of Technology, in June.
Licentiate opponent Luleå Technical University, in May.

Olofsson, Björn
Member of the grading committee for the PhD Thesis by Stefan Kojchev on May 22, 2024, Division of Mechatronics, Department of Electrical Engineering, Chalmers University of Technology, Sweden. Thesis title: *On Optimization-Based Coordination of Automated Vehicles in Confined Sites*.

Rantzer, Anders
Faculty opponent for Sribalaji Coimbatore Anand, Uppsala University, on May 30.
Member of PhD examination committee for Meng Lu, Lund University, October 18.

Tegling, Emma
Member of PhD examination committee for Liam Hamed Taghavian, KTH, in March.
Substitute member of examination committee for Pontus Ebelin at the Mathematics Centre, Lund University, in March.

ADVISORY COMMITTEES AND WORKING GROUPS

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

Bernhardsson, Bo
Member of the AI Lund coordination group.

Como, Giacomo
Chair of the IEEE-CSS Technical Committee on Networks and Communications.

Eker, Johan
Co-organized the Real-time Cloud workshop in Lille as part of ECRTS 2023.
Organized 1st WARA-Ops workshop in Lund, in May.
Participated in the panel for the WASP Industry Days, in November.
Participated in the panel for the KK-foundation 30 celebration event, in October.
Chair at the session on compute offloading at the 17th Cloud Control Workshop, in June.

Johnsson, Charlotta
Part of UD:s referensgrupp för internationell standardisering (Referece group for international standardization, Ministry for Foreign Affairs, Sweden).
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 working groups at Lund University, e.g Samverkansrådet 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).
Part of ELLIIT Gender and Diversity Group.

Maggio, Martina
Program Chair: International Conference on Embedded Software (EMSOFT).
Program Committee Membership: Euromicro Conference on Real-Time Systems (ECRTS).

Pates, Richard
Part of the Council of the European Control Association.

Rantzer, Anders
Member of review panel for projects funded by the European Research Council.
Member Evaluation Committee for Wallenberg Academy Fellows.
Advisory Editor 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.

Soltesz, Kristian
IEEE Technical Committee on Healthcare and Medical System.

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.
Member of the Sectoral Competition Commission of the All-Ukrainian Competition of Student Scientific Works in the Specialty "Electronics".

OTHER ASSIGNMENTS

Årzén, Karl-Erik
Associate Editor for Real-Time Systems Journal.
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
Authored a chapter on *Stability and Lyapunov Theory* in the Encyclopedia of Systems and Control Engineering, Elsevier.
Associate Editor for IEEE/ASME Transactions on Mechatronics since August 2024.
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 IEEE International Conference on Robotics and Automation (ICRA) for ICRA22, ICRA23.

Maggio, Martina
Expert evaluator for Mälardalen University and Uppsala University (for docent applications, promotions and new hires).
Associate Editor of the ACM Transactions on Embedded Computing and ACM Transactions on Cyber-Physical Systems.

Pates, Richard
Associate Editor for Control Systems Magazine.

Rantzer, Anders
Director of the ELLIIT Focus Program.

Soltesz, Kristian
Program director of the Engineering Physics program at Lund University.

Tegling, Emma
Secretary of the European Control Association (until June 2024).

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

LONGER VISITS ABROAD

Bakovic, Luka
During autumn, Luka Bakovic was on a four month visit to the Department of Mathematical Sciences at Politecnico di Torino.

Hansson, Jonas
During spring Jonas Hansson spent a two-month research visit at UC Santa Barbara, collaborating with Prof. Bassam Bamieh and Prof. Francesco Bullo.

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 the main part of 2024 she had only 20% duty at the Department of Automatic Control, Lund University.

Ohlin, David
David Ohlin spent the fall of 2024 as a visiting scholar at UC Berkeley with the research group led by Murat Arcak.

Upadhyaya, Manu
From September to February 2025, Manu Upadhyaya spent a research stay with the Sierra team at Inria Paris, hosted by Francis Bach and Adrien Taylor, to further his work on advanced optimization methods.

LECTURES BY OUR STAFF OUTSIDE THE DEPARTMENT

Åström, Karl Johan
84 minutspendeln - Hur jag blev intresserad av reglerteknik (84 minutes pendulum -How I got intrerested in Automatic Control), presentation at the event Reglerteknik 75 år, at KTH, June 29.

Bernhardsson, Bo
Svensk reglerteknik i telekom (Automatic Control in the mobile phone industry). Presentation at the event *Reglerteknik 75 år,* at KTH in June.

Eker, Johan
Keynote lecturer at the 11th International Conference on Internet of Things: *Systems, Management and Security* (IOTSMS 2024).
Keynote lecturer at the 9th International Conference on Fog and Mobile Edge Computing (FMEC 2024) – *Cloudy, with a chance of offloading.*
Invited talk the ECC 2024 workshop "Control with 6G" on *compute off-loading of control tasks.*

Giselsson, Pontus
Workshop on *Nonsmooth Optimization and Applications* University of Antwerp, Antwerp, Belgium, Apr. 8–13. Semi-plenary speaker.

Johnsson, Charlotta
Historical Female Influencers in Automatic Control, presentation for Japanese delegation at LTH, February 9.
Hur skapar man en kreativ, öppen och innovative företagskultur?, Hot spot med EFL, Lund, April 12.
Reglerteknik 75 år – var är kvinnorna?, presentation at the national celebration ceremony for 75 years with Automatic Control in Sweden, June 29**.**

Gender mainstreaming in Automatic control, Workshop at University of Mauritius, September 20.
Hur skapar man en kreativ, öppen och innovativ företagskultur?, Hot spot med EFL, Helsingborg, November 29.

Maggio, Martina
Invited Semi-plenary Lecture, European Control Conference (ECC 2024).
Invited Keynote, Real-time And intelliGent Edge computing workshop (RAGE DAC 2024).

Rantzer, Anders
On Minimax Adaptive Control, Invited seminar at Uppsala University, May 29.
On Control of Large-scale Networks}, Invited lecture at NetDyn 2024: International Workshop on Network Dynamics, Lund, August 26.
Optimal Control on Positive Cones, presentation at 63rd IEEE Conference on Decision and Control, Milan, December 16.

Tegling, Emma
Challenges in sociotechnical network systems, ELLIIT Annual Workshop, Highlight talk, Lund, in March.
From Scale Fragile Network Systems to Robust Bounded-Degree Random Graphs, International Workshop and Conference on Network Science (NetSci) Satellite on Controlling Complex Networks, Quebec, in June.

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

Westin, Eva
Historical Female Influencers in Automatic Control, presentation for Japanese delegation at LTH, February 9.

Wittenmark, Björn
*Reglerteknik 59 år (Automatic Control during 59 years)***,** presentation at the event Reglerteknik 75 år, at KTH in June 29.

POPULAR SCIENCE

Johnsson, Charlotta
Historical Female Pioneers, section in the article about IFAC Activity Fund Committee update, published in IFAC Newsletter, in February.
Lise Meitner panel discussion on Gender Equality, member of the panel, LTH, October 16.