
KTH Mathematics

# Ulf Jönsson Memorial Conference

August 27, 2012

## Program

Division of Optimization and Systems Theory
Department of Mathematics
KTH Royal Institute of Technology
Stockholm, Sweden
http://www.math.kth.se/optsyst/

## Ulf Jönsson, 1963–2011

Ulf Jönsson died from acute leukemia in May 2011 after a short period of illness. Ulf was in the midst of his successful career as professor of optimization and systems theory at KTH when he tragically passed away far too early, on his 48th birthday. His closest family was his spouse Candice Weir, his parents Tore and Essy Jönsson, and his brother Mats with wife.

Ulf was born in Barsebäck in 1963 and completed a master of science degree in electrical engineering at LTH, Lund, in 1989. A year as an exchange student at the University of California Santa Barbara sparked his interest in research, and he earned a PhD degree in automatic control from LTH in 1996. After postdoctoral appointments at MIT and Caltech, he returned to Sweden and KTH. By showing significant skill in research as well as in teaching, he was appointed full professor at KTH in 2010.

Ulf made important contributions in a range of areas within control theory and adjacent subjects. In particular, his work on handling uncertainties and nonlinearities in control of systems of high complexity has been highly appreciated. He carried out significant editorial duties in the three leading journals within his field, namely *IEEE Transactions on Automatic Control*, *Automatica* and *SIAM Journal on Control and Optimization*, which was a recognition of his expertise and scientific integrity. In addition, Ulf was a person who always put his students in focus, and gave them much support and encouragement.

Ulf was a humble and geniunely generous person. By humor and self distance he shared his discoveries, within research as well as within his leisure interests music, travel and sports. Through his decease we lost an extremely valuable colleague and friend.

Anders Forsgren, KTH
Xiaoming Hu, KTH
Anders Lindquist, KTH
Anders Rantzer, LTH
Krister Svanberg, KTH

KTH Mathematics

# Ulf Jönsson Memorial Conference

Stockholm, Sweden, August 27, 2012

**Conference Site.** The conference will be held at the Royal Institute of Technology, which is situated in the northern part of the inner city of Stockholm. It is easy to reach it by subway—take the red line towards Mörby Centrum and get off at station Tekniska Högskolan. All talks will be given in room Salongen at the KTH library, Osquars backe 31.

**Registration.** Registration to the conference can be made by e-mail to Ann-Britt Öhman (annbritt@math.kth.se) no later than Friday August 17, 2012. The conference is free of charge. Anyone is welcome to attend the seminars, but only preregistered attendees can take part in the full conference (including seminars, coffee and lunch).

**Organizing Committee.** Anders Forsgren, Xiaoming Hu and Krister Svanberg.

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**Dinner.** To honor Ulf Jönsson, a special dinner will be organized in the evening after the conference, at 19.00 on Restaurant Hasselbacken, Hazeliusbacken 20. Except for invited guests, participation in the dinner is at one's own expense. Registration to the dinner can be made by e-mail to Ann-Britt Öhman (annbritt@math.kth.se) no later than Friday August 17, 2012.

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The conference is financially supported by

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| Schedule, Monday August 27, 2012 | |
|---|---|
| 8.30– 8.45 | Registration |
| 8.45– 9.00 | Opening Remarks |
| 9.00– 9.25 | **Chung-Yao Kao**, *Analysis and synthesis under the integral quadratic constraint framework* |
| 9.25– 9.50 | **Per Enqvist**, *Robust spectral estimation for speech processing* |
| 9.50–10.15 | **Corentin Briat**, *The conservation of information and the congestion control modeling problem* |
| 10.15–10.45 | Coffee Break |
| 10.45–11.10 | **Michael Cantoni**, *Robust stability analysis via IQCs and the nu-gap metric* |
| 11.10–11.35 | **Enrico Lovisari**, *Robust synchronization of heterogeneous multi-agent systems: Analysis and applications* |
| 11.35–12.00 | **Anders Hansson**, *Distributed robust stability analysis of interconnected uncertain systems* |
| 12.00–13.30 | Lunch Break |
| 13.30–13.55 | **John Baillieul**, *Optimization of motion-mediated communication* |
| 13.55–14.20 | **Karl Henrik Johansson**, *When do distributed averaging converge in finite time?* |
| 14.20–14.45 | **Masaki Ogura**, *Random products of matrices and linear switching systems* |
| 14.45–15.15 | Coffee Break |
| 15.15–15.40 | **Anders Möller**, *Modeling and stability analysis of rate and power control in wireless communication networks* |
| 15.40–16.05 | **Bijoy Ghosh**, *Biomechanical control of human eye and head movement* |
| 16.05–16.30 | **Anders Lindquist**, *The circulant rational covariance extension problem: The complete solution* |

## List of Abstracts

**Chung-Yao Kao**

National Sun Yat-sen University, Kaohsiung, Taiwan

**9.00–9.25**

### Analysis and synthesis under the integral quadratic constraint framework

The use of integral quadratic constraint (IQC) in systems analysis has a long history. Such inequalities offer a framework for rigorous analysis of robust stability and performance, where verification of stability and robustness of specific feedback systems can be done via optimization-based algorithms. The framework unifies powerful ideas from several important research directions, which include the dissipative systems theory, the absolute stability theory, robust control theory, and computational tools from convex optimization. In this talk we will briefly review some recent developments of this approach on the synthesis front, in particular about robust estimation and robust feedforward design with dynamic IQCs. Moreover, we will give a brief introduction of a MATLAB toolbox which is designed to provide a user friendly interface for semi-automatic systems analysis and synthesis under the IQC framework.

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**Per Enqvist**

KTH Royal Institute of Technology, Stockholm, Sweden

**9.25–9.50**

### Robust spectral estimation for speech processing

In many speech processing applications it is important to estimate the envelope of the power spectral density of speech signals. Voiced speech has a harmonic structure and this causes difficulties for many estimation methods. Hence different means for increasing the robustness of the estimator have been proposed. We study some new and existing regularization techniques that have been applied on interpolation based spectral estimators and compare their performance on artificial speech. We also describe the robust methods from a Bayesian framework which could facilitate the choice of regularization method and values of design parameters.

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**9.50–10.15**

**Corentin Briat**

ETH Zürich, Zürich, Switzerland

### The conservation of information and the congestion control modeling problem

In communication networks, such as Internet, the congestion phenomenon is responsible for a reduction in network efficiency by inducing large communication delays and data loss. Modeling congestion to fully understand the phenomenon and deriving new congestion control protocols is then of great interest. Attacking the congestion problem from the systems and control theory viewpoint is not new. However, recent advances have made the models very accurate and flexible. In this talk, a complete model for congestion will be developed from a unique fundamental principle: the conservation of information; and is the fruit of my 2-year collaboration with Ulf Jönsson (but not only) when I was postdoc at KTH.

Models for transmission channels, queues and users are directly obtained from this principle. The corresponding network model hence consists of building blocks along with simple interconnection rules, as in electrical circuits (metamodel). The important properties of modularity and scalability are achieved for this model, emphasizing then the suitability of the paradigm. Comparison with NS-2 simulations and experimental results confirm the validity of the model on the considered topologies.

As a byproduct, it is also shown that previous models from the literature may be viewed as approximations of the proposed model, or shown to be exact whenever conditions on the network topology are met. Finally, linearization of the building blocks offers an easy way for locally representing any network topology, locally understanding the behavior of blocks, and deriving local stability results in a very generic way.

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**10.45–11.10**

**Michael Cantoni**

University of Melbourne, Melbourne, Australia

### Robust stability analysis via IQCs and the nu-gap metric

This talk provides an overview of work that blends the nu-gap metric and integral-quadratic-constraints (IQCs) in stability analysis for uncertain but potentially structured feedback interconnections. This includes a time-varying generalisation of the nu-gap metric. To illustrate the blended approach, the stability of an interconnection of distributed-parameter transfer functions via links with time-varying gain or delay is discussed.

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**Enrico Lovisari**

University of Padova, Padova, Italy

**11.10–11.35**

**Robust synchronization of heterogeneous multi-agent systems: Analysis and applications**

The talk presents a general framework for synchronization of heterogeneous multi-agent systems. The main concern is on Higher Order Consensus Networks, where agents are modeled as perturbed versions of a nominal common LTI operator. By local communication only, the agents compute their input to achieve output-synchronization, namely agreement on their outputs. The control and communication protocol is required to be robust with respect to uncertainties in the dynamics of the agents. A general result based on the flexible theory of Integral Quadratic Constraints is proposed to solve the problem. The second part of the talk is concerned with the important applicative problem of clocks synchronization. Following a popular model, clocks are represented as double integrators whose outputs are their time readings. The previous result is used to refine the analysis of a known control protocol by giving a characterization of the maximum difference among the clocks that still allows synchronization to take place.

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**Anders Hansson**

Linköping University, Linköping, Sweden

**11.35–12.00**

**Distributed robust stability analysis of interconnected uncertain systems**

This talk considers robust stability analysis of a large network of interconnected uncertain systems. To avoid analyzing the entire network as a single large, lumped system, we model the network interconnections with integral quadratic constraints. This approach yields a sparse linear matrix inequality which can be decomposed into a set of smaller, coupled linear matrix inequalities. This allows us to solve the analysis problem efficiently and in a distributed manner. We also show that the decomposed problem is equivalent to the original robustness analysis problem, and hence our method does not introduce additional conservativeness.

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**13.30–13.55**

**John Baillieul**

Boston University, Boston, Massachusetts, USA

**Optimization of motion-mediated communication**

During an all too brief career, the late Ulf Jönsson pushed back the frontiers of both nonlinear and periodic systems and became a world leader in classical robust and optimal control theory. Inspired by the advances he made, this talk will introduce a new class of problems in optimized communication by means of the dynamics of a control system. To provide background, the nascent theory of control communication complexity is surveyed. The standard parts optimization problem is introduced, and new results regarding optimal ensemble averaged motions sequences are presented. Distributed control of dynamical systems defined on Lie groups is discussed in connection with recent experimental work on optimized rf-pulse design for controlling quantum spin systems.

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**13.55–14.20**

**Guodong Shi, Mikael Johansson and Karl Henrik Johansson**

KTH Royal Institute of Technology, Stockholm, Sweden

**When do distributed averaging converge in finite time?**

Distributed control, estimation, and computing are important for many emerging applications. The asymptotic stability of distributed algorithms has been studied for a long time. This talk will discuss finite-time convergence of distributed averaging and maximizing algorithms. A generalized consensus algorithm which unifies distributed averaging and maximizing is introduced. We show that finite-time consensus is almost impossible for distributed averaging algorithms under this unifying model, while distributed maximizing converges in finite time. For graphs defined by a $\mu$-nearest-neighbor rule, where each node interacts with its $\mu$ nearest smaller neighbors and the $\mu$ nearest larger neighbors, we show that $\mu + 1$ is a threshold for the total number of network nodes for distributed averaging to reach consensus in finite time. Interestingly enough, this critical number of nodes is $2\mu$ if each node interact only with neighbor nodes having distinct values. For so called gossip algorithms, in which each node exchanges information only with one neighbor node at each time slot, we show that the algorithm converges in finite time if and only if the number of network nodes is a power of two. We also show that the set of initial values for which there exists a finite-time convergent gossip algorithm has measure zero when the number of nodes is not a power of two. This conclusion follows from a quite general "all-or-nothing" theorem stating that for a class of averaging algorithms defined by matrix sequences selected from a countable set of stochastic matrices, finite-time convergence either holds for all initial conditions, or fails for almost all initial conditions.

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**Clyde Martin and Masaki Ogura**

Texas Tech University, Lubbock, Texas, USA

**14.20–14.45**

**Random products of matrices and linear switching systems**

There is a rich literature about random products of matrices. In this talk we study some of the connections of that literature to linear switching systems. First we study switching Riccati differential equations that is induced by linear switching systems. It is shown that the expected value of the escape time satisfies an integral equation and then give a sufficient condition for the equation to admit a unique solution. Then we study a random walk on so called Grassmannian manifold driven by a linear switching system. We show that the limiting distribution of the random walk converges to a unique invariant measure exponentially fast.

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**Anders Möller**

KTH Royal Institute of Technology, Stockholm, Sweden

**15.15–15.40**

**Modeling and stability analysis of rate and power control in wireless communication networks**

Wireless data traffic in cellular networks is currently undergoing a strong global expansion and the demand for high and reliable data throughput increases. Capacity is, however, a limited resource, and in radio resource management a trade-off has to be made between the congestion level, related to cell coverage and interference levels, and the Quality of Service (QoS) or data rates of the users. The radio channel conditions vary on a fast time scale and the measurements of the received signals are subject to disturbances and uncertainties. This motivates the use of control strategies to update the transmission powers. In fact, in implementations of uplink in cellular networks, the performance of the network is ensured by using a fast inner power control algorithm to track a QoS-target and a slower outer control algorithm to limit congestion. Several theoretical challenges arise in this problem setting. Due to the nature of the network, both information and control are distributed. Furthermore, measurements of the congestion and the QoS are used in the control loops, which introduces nonlinear feedback. Another complicating factor is that filtering, computations and information exchange in the network cause time-delays and dynamics. In this talk we address these challenges by using modeling and analysis tools in systems and control.

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**15.40–16.05**

**Bijoy Ghosh**

Texas Tech University, Lubbock, Texas, USA

**Biomechanical control of human eye and head movement**

Human head movement can be looked at, as a rotational dynamics on the space SO(3) with constraints that have to do with the axis of rotation. In general, Donders' Law specifies that the axis of rotation has a small torsional component that can be expressed as a function of the horizontal and vertical components. Recently, head movements have been compared to that of a gimbal originally constructed by Fick. The claim is that the head has its "yaw axis" fixed relative to the trunk, the "pitch axis" moves with the head, and there is no roll. In this talk, we reexamine Fick's Law by examining experimental data from different human head maneuvers. The model head movement trajectories are constructed using a suitable Riemannian Metric on the constrained space of rotation matrices, together with a suitable form of "coordinate free" potential energy and a damping term. Optimal head movement trajectories are obtained, where the goal is to optimize a quadratic cost function on the energy of the applied control torques and where the states are allowed to move between an initial and a final point. The model trajectories are compared with observed trajectories of human head movement.

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**16.05–16.30**

**Anders Lindquist**

KTH Royal Institute of Technology, Stockholm, Sweden

**The circulant rational covariance extension problem: The complete solution**

The rational covariance extension problem to determine a rational spectral density given a finite number of covariance lags can be seen as a matrix completion problem to construct an infinite-dimensional positive-definite Toeplitz matrix, the north-west corner of which is given. The circulant rational covariance extension problem considered in this talk, which is based on joint work with Giorgio Picci, is a modification of this problem to partial stochastic realization of reciprocal and periodic stationary process, which are better represented on the discrete unit circle $\mathbb{Z}_{2N}$ rather than on the discrete real line $\mathbb{Z}$. The corresponding matrix completion problem then amounts to completing a finite-dimensional Toeplitz matrix that is circulant. The circulant rational covariance matrix is an inverse problem with infinitely many solutions in general, each corresponding to a bilateral ARMA representation of the underlying periodic (reciprocal) process. In this paper we present a complete smooth parameterization of all solutions and convex optimization procedures for determining them. This problem has applications to image processing.

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## List of Speakers

- **John Baillieul**, (johnb@bu.edu), Boston University, Boston, Massachusetts, USA. *Optimization of motion-mediated communication.* (13.30–13.55, Abstract on p. 8).
- **Corentin Briat**, (corentin@briat.info), ETH Zürich, Zürich, Switzerland. *The conservation of information and the congestion control modeling problem.* (9.50–10.15, Abstract on p. 6).
- **Michael Cantoni**, (cantoni@unimelb.edu.au), University of Melbourne, Melbourne, Australia. *Robust stability analysis via IQCs and the nu-gap metric.* (10.45–11.10, Abstract on p. 6).
- **Per Enqvist**, (penqvist@kth.se), KTH Royal Institute of Technology, Stockholm, Sweden. *Robust spectral estimation for speech processing.* (9.25–9.50, Abstract on p. 5).
- **Bijoy Ghosh**, (bijoy.ghosh@ttu.edu), Texas Tech University, Lubbock, Texas, USA. *Biomechanical control of human eye and head movement.* (15.40–16.05, Abstract on p. 10).
- **Anders Hansson**, (anders.g.hansson@liu.se), Linköping University, Linköping, Sweden. *Distributed robust stability analysis of interconnected uncertain systems.* (11.35–12.00, Abstract on p. 7).
- **Karl Henrik Johansson**, (kallej@kth.se), KTH Royal Institute of Technology, Stockholm, Sweden. *When do distributed averaging converge in finite time?.* (13.55–14.20, Abstract on p. 8).
- **Chung-Yao Kao**, (cykao@mail.nsysu.edu.tw), National Sun Yat-sen University, Kaohsiung, Taiwan. *Analysis and synthesis under the integral quadratic constraint framework.* (9.00–9.25, Abstract on p. 5).
- **Anders Lindquist**, (alq@kth.se), KTH Royal Institute of Technology, Stockholm, Sweden. *The circulant rational covariance extension problem: The complete solution.* (16.05–16.30, Abstract on p. 10).
- **Enrico Lovisari**, (lovisari@dei.unipd.it), University of Padova, Padova, Italy. *Robust synchronization of heterogeneous multi-agent systems: Analysis and applications.* (11.10–11.35, Abstract on p. 7).
- **Anders Möller**, (amolle@kth.se), KTH Royal Institute of Technology, Stockholm, Sweden. *Modeling and stability analysis of rate and power control in wireless communication networks.* (15.15–15.40, Abstract on p. 9).
- **Masaki Ogura**, (masaki.ogura@ttu.edu), Texas Tech University, Lubbock, Texas, USA. *Random products of matrices and linear switching systems.* (14.20–14.45, Abstract on p. 9).