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What are moment problems and why are they useful in systems and control?

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Abstract:

Moment problems are ubiquitous throughout engineering, mathematics and science, and particularily at their interface. Power moments of probability measures play an important role in partial statistical modeling and in its application to information theory, communications, signals and systems. Applications of the trigonometric moment problem to systems and control also have a long and fruitful history, including the rational covariance extension problem for modeling a finite time window of a stochastic process. Analytic interpolation problems are an important class of moment problems with applications to circuit theory, power systems, robust control, signal processing, spectral estimation and stochastic realization theory. Moment problems are typically underdetermined and give rise to families of particular solutions, and finding a solution that also satisfies a natural optimality criterion or design specification is an important general problem. In this lecture we pose and solve a nonclassical version of this problem (which we call the moment problem for positive rational measures) that reflects the importance of rational functions in signals, systems and control. While this version of the problem is decidedly nonlinear, there exists a natural, universal family of strictly convex optimization criteria defined on the convex set of particular solutions. This provides a powerful paradigm for smoothly parameterizing, comparing and shaping the solutions based on various additional design criteria. It also enables us to establish the smooth dependence of solutions on problem data. During this lecture, we will motivate and illustrate these results by applications to robust control and signal processing.

Biography:

Anders Lindquist received his PhD degree from the Royal Institute of Technology, Stockholm, Sweden, where in 1972 he was appointed a Docent of Optimization and Systems Theory. From 1972 to 1974 he held visiting positions at the University of Florida, Brown University, and the State University of New York at Albany. In 1974 he became an Associate Professor, and in 1980 a (full) Professor of Mathematics at the University of Kentucky, where he remained until 1983. He is now a Professor at the Royal Institute of Technology, where in 1982 he was appointed to the Chair of Optimization and Systems Theory. Since then he has also held visiting positions at the University of Padova and Consiglio Nazionale delle Ricerche, Italy, Arizona State University, International Institute of Applied Systems Analysis, Vienna, Russian Academy of Sciences, Moscow, East China Normal University, Shanghai, Technion, Haifa, University of California at Berkeley, and University of Kyoto, Japan. Since 1989 he is an Affiliate Professor at Washington University, St Louis. From 2000 until December 2009 he was the Head of the Mathematics Department at the Royal Institute of Technology.

Presently, Anders Lindquist is the Director of the Strategic Research Center for Industrial and Applied Mathematics (CIAM) at the Royal Institute of Technology. He is a Member of the Royal Swedish Academy of Engineering Sciences, a Foreign Member of the Russian Academy of Natural Sciences, a Fellow of IEEE (Institute of Electrical and Electronics Engineers), an Honorary Member the Hungarian Operations Research Society, a Fellow of SIAM (Society for Industrial and Applied Mathematics), a Fellow of IFAC (International Federation of Automatic Control), and a Life Fellow of IEEE. He was awarded the 2009 W.T. and Idalia Reid Prize in Mathematics from SIAM and the 2003 George S. Axelby Outstanding Paper Award of the IEEE Control Systems Society (CSS). He received an Honorary Doctorate (*Doctor Scientiarum Honoris Causa*) from Technion (Israel Institute of Technology), Haifa, in June 2010.

Lindquist is presently on the editorial boards of *SIAM Review* and *Acta Automatica Sinica*. He has served on many other editorial boards of journals, among them the *Journal of Mathematical Systems, Estimation, and Control* (Communicating Editor), *Systems and Control Letters*, and *Adaptive Control and Signal Processing*, as well as book series, namely *Systems and Control: Foundations and Applications*, *Applied and Computational Control, Signals, and Circuits*, and *Progress in Systems and Control*. Since 1983 he has been a member, and between 1985 and 1987 the chairman, of the steering committee for the biennial international symposia on the Mathematical Theory of Networks and Systems (MTNS). For the first half of 2003, he served as the scientific leader at Institut Mittag-Leffler.