Computational and Optimization Methods for Control Systems, Ankara, Turkey, August, 2011.

Lecturer:

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Purpose: This workshop is designed to give a complete overview of of the state-of-the-art computational methods and the associated software for computer-aided control systems design and analysis.

Importance of the Workshop: During the last two decades, numerically viable algorithms and associated software have been developed for most of the important tasks arising in control systems design and analysis. Unfortunately, these techniques and the software do not seem to be widely known and/or are not being widely used by a broad group of control theorists and practicing engineers. The primary reason for this appears to be that of an understanding, efficient implementations, and making appropriate modifications of these methods as needed for applications of special interests, which require an interdisciplinary knowledge and expertise of scientific computing, control theory, and computer science; and such a combined expertise is hard to acquire without spending a great deal of time taking many diversified courses in different disciplines. What is needed, therefore, is a self-sufficient course that can explain the the computational algorithms and software in a *rather elementary and user-friendly way, without going into the depth of the associated numerical linear algebra techniques and relevant mathematical theory.* The proposed course aspires to do just that. The lectures will be organized to clearly explain the algorithms in a manner that is suitable for easy implementations on computers. The important aspects of implementations will be discussed, a clear and concise comparative study of one algorithm over the others for a given problem will be presented, based on that study, and recommendations, will be made for the engineers. *Mathematical and computational jargon that seem to be distractive for most engineers and other applied scientists to learn these techniques, will be avoided.* The minimal amount of numerical linear algebra background that is absolutely essential to understanding the material will be presented in the course itself, in a conceptual way, by giving the details of software and implementational issues.

Potential Benefits and Impact of the Workshop: In recent years, there has been a surge of applications of control techniques in many important areas of science and engineering, including *Aerospace, Automotive, Medicines, Biology, Power Systems, Structural Dynamics,*

Manufacturing Engineering, and others. For successful applications of these techniques with a view to solving practical-life problems, it is crucial that the control techniques, needed by these applications, are properly implemented using numerically, robust, computational methods and software.
The participants of this workshop will be exposed to the essential state-of-the-art useful computational techniques and software for control systems design and analysis, which can be used and further developed (as needed) in future research, teaching, and practical work applications. The workshop will also provide motivation and practical guidance to the instructors teaching linear systems theory courses to include some state-of-the-art numerical techniques and software in their existing courses and/or design an exclusive graduate-level course in this area.

Topics: All fundamental topics will be covered. These include:

- Modeling
- System Responses
- Numerical tests for Controllability, Observability and Distance to Uncontrollability
- Stability, Robust Stability and Distance to Instability Feedback Stabilization, Optimal and H-infinity Control
- Numerical Solutions and Conditioning of Lyapunov, Sylvester and Algebraic Riccati Equations
- A Brief Introduction to System Identification
- Algorithms for Balanced Realization and Model Reduction
- Numerical Algorithms and Conditioning of Pole-placement
- Algorithms for Observer Design (state-estimation) and Kalman Filtering for Stochastic Systems
- Control Software
- Current Research on Active Vibration Control

Intended Audience: Graduate students and researchers in all areas of engineering and applied sciences, along with practicing engineers working on control and control- related applications in aerospace, automobiles, medicine, space-sciences, structural dynamics, manufacturing, robotics, power systems, and many others.
The workshop will also be of interest to *applied and computational mathematicians and other scientists* desirous of learning how linear algebra problems arise in control systems design and analysis and are solved using sophisticated techniques of numerical linear algebra.

Background: A first course in *Linear Control Systems and in Numerical Linear Algebra* will be helpful. Required numerical linear algebra topics will be reviewed during the lectures as needed.

References:

BOOKS:

- Numerical Methods for Linear Control Systems Design and Analysis, by Biswa Nath Datta, Elsevier Academic Press, 2003.
- Numerical Linear Algebra and Applications, Second Edition, by Biswa Nath Datta, SIAM Publications, 2010.

Software Manuals:

- MATLAB Control Systems Toolbox
- MATHEMATICA-based Control Systems Professional-Advanced Numerical Methods by Biswa Datta and Daniil Sarkissian, Wolfram Research Incorporation, 2003.
- MATCONTROL (MATLAB-based Toolkit accompanying the Book "Numerical Methods for Linear Control Systems Design and Analysis").
- MATCOM (MATLAB-based Toolkit for Matrix Computations accompanying the book "Numerical Linear Algebra and Applications").

ABOUT THE LECTURER (Biswa Nath Datta)

Biswa Nath Datta is a Professor of Mathematical Sciences, an Adjunct Professor of Electrical and Mechanical Engineering and a *Distinguished Research Professor* at Northern Illinois University.
Professor Datta has held visiting professorship at *University of Illinois- Urbana-Champaign*, *Pennsylvania State University*, *University of California-San Diego*, *State University of Campinas*, Brazil, as well as at many other universities and research laboratories around the world, including the *Boeing Company*.

His research interests are interdisciplinary, blending linear and numerical linear algebra with control and systems theory, along with vibration engineering. He is an *IEEE Distinguished Lecturer*, a *IEEE Fellow* and an *"Academician"* of the Academy of Nonlinear Sciences (Russia). He is a recipient of several IEEE plaques of honor, the IFNA (International Federation of Nonlinear Analysis) award, the US-State Department *Senior Fulbright Specialist Award*, 2006 and 2008. He received a **Gold Medal of Honor** in a special honoring ceremony held at the *First International Conference on Power, Control, Signals and Computation*, held in Thrissur, India, January 2010. He was also honored at a special IEEE honoring ceremony during the banquet of the *International Workshop on Numerical Linear Algebra in Signals, Systems and Control*, held in IIT-Kharagpur, India, January 2007 for his "outstanding contributions in numerical linear algebra related to control" and at the banquet-honoring ceremony held on the occasion of the IMA Sponsored *International Conference on Linear and Numerical Linear Algebra: Theory, Methods and Applications*, held at Northern Illinois University, DeKalb, Illinois, in August 2009.
In recognition of his outstanding contributions, a book, entitled **Numerical Linear Algebra in Signals, Systems, and Control**, will be published by *Springer* in 2011. Also will be published in 2011 in his honor a special issue of the journal, **Numerical Linear Algebra with Applications** on *Inverse Problems in Science and Industry*.

Professor Datta is the author of more than 120 interdisciplinary research papers, two books entitled **Numerical Linear Algebra and Applications**, SIAM Publications, 2010 and **Numerical Methods for Linear Control Systems Design and Analysis**, Elsevier Academic Press, 2003 along with three software packages, *Control Systems Professional-Advanced Numerical Methods*, Wolfram Research Incorporation, 2003, and MATLAB -based toolkits *MATCONTROL and MATCOM*. He has served or is presently serving on the editorial board of premier journals, such as *SIAM J. Matrix Analysis and Applications*, *Linear Algebra and its Applications (special editor)*, *Numerical Linear Algebra with Applications*, *the Journal of Mathematical Systems, Estimation, and Control*, *Mechanical Systems and Signal Processing*, *Computational and Applied Mathematics (Brazil)*. He is the **Founding Editor** and the **Editor-in-Chief** of the annual series: *Applied and Computational Control, Signals, and Circuits*. He has also edited four interdisciplinary books and several interdisciplinary special issues of some of the above mentioned journals.

He has delivered a large number of **Plenary** and **Key-Note** addresses and short courses/workshops at international conferences, along with numerous colloquium talks at universities and research laboratories around the world.

He also organized and chaired/co-chaired the *AMS-IMS-SIAM Joint Summer Research Conference on Linear Algebra and its Role in Systems Theory*, in 1984; the *SIAM Conference on Linear Algebra in Signals, Systems, and Control*, in 1986, 1988, 1993, and 2001; the *Mathematical Theory of Networks and Systems (MTNS)*, in 1996, and numerous interdisciplinary invited special sessions on control, systems, and signal processing at international conferences.