

“State of the Art Computational Methods and Software for Computer-Aided Control Systems Design and Analysis” to be delivered at Centro de Pesquisas de Energia Eltrica - Cepel, Rio de Janeiro, RJ, Brazil - June 2010.

Lecturer:

1. **Biswa Nath Datta**, *IEEE Fellow and Distinguished Research Professor*, Northern Illinois University, DeKalb, Illinois, USA.
E-mail : dattab@math.niu.edu
URL: www.math.niu.edu/ dattab

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 an understanding, efficient implementations, and making appropriate modifications of these methods as needed for applications of special interests, 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 by taking many diversified courses in different disciplines. What is needed, therefore, a self-sufficient course that can explain 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 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 clearly discussed, a clear and concise comparative study of one algorithm over the others for a given problem will be presented and recommendations, based on that study, 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 are absolutely essential to understand the material will be presented in the course itself in a conceptual way, but giving the details of software and implementational issues.

Potential Benefits and Impact of the Workshop : In recent years, there have 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 confidence in future research, teaching, and work on practical 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 a exclusive graduate level course in this area.

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

- Modeling
- System Responses
- Numerical tests for Controllability, Observability
- 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, and practicing engineers working on control and control related applications in aerospace, automobile, medicine, space-sciences, structural dynamics, manufacturing, robotics, power systems and many others. Engineers working in all areas of engineering and applied sciences working on control and control related applications and practicing engineers and applied scientists in all areas of engineering working on control and control applications

The workshop will also be of interest to *applied and computational mathematicians and other scientists* desirous of learning of 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".
- MATCOMMATLAB-based Toolkit for Matrix Computations accompanying the book "Numerical Linear Algebra and Applications".