MINI-COURSE ON

**"State of the Art Computational Methods and Software for Computer-Aided Control Systems Design and Software", Universidade de Aveiro, Departamento de Matemtica, Aveiro, Portugal, 14-15 Dezembro, 2005**.

**Lecturer**:

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**Purpose**: This two-day mini-course is designed to give a complete overview of of the state-of-the-art computational methods and the associated software for control systems design and analysis.

**Importance of the Workshop**: During the last two decades, numerically viable algorithms have been developed for most of the important tasks arising in control systems design and analysis. Softwares based on these methods have been developed and are still being built. Unfortunately, these techniques and the softwares 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 some 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, and taking many diversified courses in different disciplines. What is needed, therefore, 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 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 algorithms over the others for a given problem will be presented and recommendations, based on that study, will be made for the practicing 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 and Distance to Uncontrollability
- Stability, Robust Stability and Distance to Instability
- Numerical Solutions and Conditioning of Lyapunov and Algebraic Riccati Equations
- Optimal and H-infinity Control
- System Identification
- Algorithms for Balanced Realization, Model Reduction and Hankel-Norm Approximations.
- Numerical Algorithms and Conditioning of Pole-placement
- Algorithms for Observer Design, Kalman Filtering and LQG Design  item Control Software

**Software**:

- MATLAB-based Control System Toolbox
- SLICOT - A Fortran Subroutine Library in Systems and Control Theory
- Control Systems Professional: Advanced Numerical Methods - A MATHEMATICA Based State-of-the-art Control Library
- MATCONTROL - A MATLAB-based Control Systems Educational Tool Box, developed by Biswa Datta

**Intended Audience**: Graduate Students and Researchers in control and systems, and practicing control and systems engineers and applied scientists working on a wide variety of control applications, including *aerospace, automotive, biology, medicine, space-sciences, structural and manufacturing engineering, robotics, power systems.* and many others. The course will also be of interests 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.

**Lecture Notes**: Detailed Lecture Notes are available at:

`http://www.mat.ua.pt/delfim/biswa/workshop05.pdf`

**References**:

**BOOK:** *Numerical Methods for Linear Control Systems Design and Analysis, by Biswa Nath Datta, ELSEVIER/ Academic Press, 2003.*

**Software Manuals**: *MATLAB Control Systems Tool Box, MATHEMATICA-based Control Systems Professional- Advanced Numerical Methods, and SLICOT.*