DEPARTMENT OF MECHANICAL ENGINEERING
WILLIAM MAXWELL REED SEMINAR SERIES

" A Novel Computational Framework for the Numerical Solution of Complex Constrained Optimal Control Problems."

Anil V. Rao, Ph.D.
Department of Mechanical and Aerospace Engineering, University of Florida

Abstract:
A novel computational framework is described for solving complex constrained nonlinear optimal control problems. The framework has a wide variety of applications in aerospace and mechanical engineering. The basis of the framework is the new class of *hp*-adaptive Gaussian quadrature methods that transcribe the continuous optimal control problem to a finite-dimensional nonlinear optimization problem. The *hp*-adaptive methods have the feature that high accuracy can be obtained with a significantly smaller mesh when compared with traditional fixed-order methods while accurately capturing nonsmoothness or rapidly changing behavior. The *hp*-adaptive methods employed using advanced sparse nonlinear programming (NLP) solvers. The derivatives required by the NLP solvers are obtained using a new approach to algorithmic differentiation where efficient derivative source code is produced through a method that combines operator overloading with source transformation. The mathematical foundation of the framework is provided and examples are given that demonstrate the improvement over previously developed approaches. Finally, future directions of the approach are discussed.

Speaker Bio:
Anil V. Rao earned his BS in mechanical engineering and AB in mathematics with distinction from Cornell University, his MSE in aerospace engineering from the University of Michigan, and his MA and PhD from Princeton University. After earning his PhD, he joined The Aerospace Corporation in Los Angeles, California. Subsequently, he was a Senior Member of the Technical Staff at The Charles Stark Draper Laboratory in Cambridge, Massachusetts. Concurrent with his employment at Draper, from 2001 to 2006 he was an adjunct faculty in the Department of Aerospace and Mechanical Engineering at Boston University where he taught the core undergraduate dynamics course. Since 2006 he has been a member of the faculty in the Department of Mechanical and Aerospace Engineering at the University of Florida where he is currently a Professor, University Term Professor, and the director of the Vehicle Dynamics and Optimization Laboratory. His research interests include computational methods for optimal control and trajectory optimization, nonlinear optimization, space flight mechanics, orbital mechanics, guidance, and navigation. In addition, he has co-authored the well-received textbook *Dynamics of Particles and Rigid Bodies: A Systematic Approach* (Cambridge University Press, 2006). He is active in many professional societies as an Associate Editor of the Journal of Spacecraft and Rockets and the Journal of Optimization Theory and Applications. He has co-developed with his students the optimal control software programs GPOPS, CGPOPS and GPOPS-II and the algorithmic differentiation software ADiGator. He has won numerous teaching and research awards in his career including the Department Teacher of the Year awards at Boston University (2002 and 2006) and the University of Florida (2008), the College of Engineering Outstanding Teacher of the Year Award at Boston University (2004), the Book of the Year Award at Draper Laboratory (2006), and the Pramod P. Khargonekar Junior Faculty Award (2012) at the University of Florida. Dr. Rao is a Member of the Society for Industrial and Applied Mathematics, an Associate Fellow of the American Institute of Aeronautics and Astronautics, and is a Fellow of the American Astronautical Society.

Date: Monday, March 7, 2022 **Time: 3:00 PM EST**
Place: Whitehall Classroom Building 106 **Contact: Dr. Alexandre Martin 257-4462**

Attendance open to all interested persons

College of Engineering

DEPARTMENT OF MECHANICAL ENGINEERING
UNIVERSITY OF KENTUCKY
LEXINGTON, KENTUCKY