Dwight Look College of
ENGINEERING
TEXAS A&M UNIVERSITY

SEMINAR

SYSTEMS, CONTROLS, AND ROBOTICS SEMINAR SERIES

Dr. John Junkins
Distinguished Professor of Aerospace Engineering
Texas A&M University
junkins@tamu.edu

Wednesday, November 6, 2013
4:00 p.m. / 100 Harrington Education Classroom Center

Nonlinear Dynamics And Control: Fusion of Regularization, Picard Iteration and Orthogonal Approximation

ABSTRACT

This seminar addresses fundamental issues at the heart of computing the state evolution for continuous-time nonlinear dynamical systems. We consider the fusion of regularizing transformations, Picard Iteration, and orthogonal approximation to devise novel solution strategies for important systems of nonlinear differential equations.

The physical behavior of a given system can typically be modeled using an infinity of coordinate choices, and the associated differential equations are therefore dependent on these analyst decisions. We will illustrate how transformations of independent and dependent state variables can regularize (remove singularities) that complicate algorithms in an original choice of coordinates. Coordinate transformation is considered in tandem with the use of a “Picard Path Iteration” approach to approximating the trajectories ensuing from a differential equation model. While we present general ideas, we focus on particular applications to specific dynamical systems. In particular, we address the most important problem in celestial mechanics, namely solving the differential equations governing orbital motion in the vicinity of a general “potato” shaped planet with a gravity field represented by a high degree spherical harmonic expansion. This classical problem is central to dynamical astronomy; accordingly, it has drawn the attention of a who’s who of mathematicians, physicists, astronomers and engineers since K. F. Gauss. Since the dawn of modern computing, the challenge of numerically solving differential equations has spawned a family of single-step (e.g., Runge-Kutta) and multi-step (e.g. Adams-Moulton, Gauss-Jackson) algorithms for solving differential equations that have been widely adopted for computational dynamical systems. It is therefore surprising (shocking, actually), that orders of magnitude speedup can be achieved over existing methodology for solving high precision motion, and more especially so for the most fundamental initial value problem in dynamical astronomy and astrodynamics. We have also shown that the corresponding two-point boundary value problems (e.g., Lambert’s Problem for orbit transfer and those flowing from Pontryagin’s Principle) can frequently be solved, *without local linearization or using a shooting method*. The algorithms discussed are also well suited to parallel computation, and as a consequence, two orders of magnitude of further speedups through implementation on inexpensive Graphical Processing Units are readily achieved, and thereby, supercomputer speedups of about four orders of magnitude can be obtained on a personal computer.

These results have immediate application to a most vexing modern challenge to our dependence on, and future utilization of, satellites in near earth orbits: Estimation of future states of >2,000 operational satellites along with >20,000 derelicts and orbital debris objects, to avoid future collisions and the increasingly likely unstable evolutionary increase in the probability of collision, known as the *Kessler Syndrome.*

BIO

Dr. John L. Junkins, a distinguished professor of aerospace engineering at Texas A&M University, and holds the Royce E. Wisenbaker Chair in Engineering. Junkins joined the faculty at Texas A&M in 1985 as the first endowed chair holder in the Dwight Look College of Engineering. A member of the National Academy of Engineering, he currently serves at the director of the Land Air and Space Robotics (LASR) Laboratory and is also director of the Texas A&M University Institute for Advanced Study (TIAS). Dr. Junkins is also a Fellow of the American Institute of Aeronautics and Astronautics, the American Society of Astronautics, and the International Academy of Astronautics. His research contributions have been recognized by a number of previous awards, including the Theodore von Karman Medal and Lectureship from AIAA in 1997. He has also received Outstanding Alumnus Awards from Auburn University and the University of California at Los Angeles.

Dr. Junkins held previous appointments at the University of Virginia and Virginia Polytechnic Institute. He began his career at age 19 when he joined NASA in 1962 to work on the Apollo program. Dr. Junkins' research has contributed extensively, over the past three decades, to the development of spacecraft navigation, guidance, and control. He has recently invented patented laser sensing technology for applications in navigation, machine vision and multimedia. Dr. Junkins' ideas have been implemented successfully in many space missions. He has over 350 publications.

Pizza and drinks will be served at 4:00 p.m.