SAN DIEGO STATE UNIVERSITY

Department of Aerospace Engineering

# SEMINAR

## Picard-Chebyshev Numerical Integration and Optimal Control: Applications in Astrodynamics

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**Engineering Building Room E 427**

**Abstract:**

This seminar is divided into three sections where the common thread is the Picard-Chebyshev numerical integration method. In the first section I discuss an adaptive, self-tuning, Picard-Cheyshev numerical integrator for propagating orbits considering high fidelity perturbed two-body dynamics. The adaptation technique is self-tuning and adjusts the size of time interval segments and the number of nodes per segment automatically to achieve near-maximum efficiency. The technique also utilizes recent insights on local force approximations and adaptive force models that take advantage of the fixed-point nature of Picard iteration. An integral quasi-linearization error feedback term is introduced that accelerates convergence to a near machine precision solution by about a factor of two. In the second section I discuss the unified Lambert tool that I developed for solving multiple revolution orbit transfer problems. The method of particular solutions is used for solving the two-point boundary value problem (TPBVP) with the Picard-Chebyshev integrator. This unique combination affords an avenue for increased efficiency that is not available with other step-by-step integrators and TPBVP solvers. Namely, the particular solutions lie in the linear domain and since the Chebyshev nodes converge to fixed points in space along the trajectory, local force approximations can be made that increase computational efficiency without degrading accuracy. In the final section I present a method for solving for optimal, minimum-fuel, low thrust orbit transfers considering a high fidelity spherical harmonic gravity model. The algorithm is formulated via the indirect variational calculus approach, leading to a two-point boundary value problem and a switch function. A hyperbolic tangent smoothing law is used on the thrust magnitude to reduce the sharpness of the control switches in early iterations and thus promote convergence. The method of particular solutions is used for solving the optimal control TPBVP with the Picard-Chebyshev integrator.

**Biography**

Robyn Woollands is an Aerospace Engineer in the Mission Design and Navigation Section at NASA's Jet Propulsion Laboratory and an Adjunct Assistant Professor at Texas A&M University. Her work involves mission design for the Europa Lander mission concept, navigation for the Mars Reconnaissance Orbiter, and research and technology development for various mission concepts involving optimal low thrust trajectory design. Robyn received her PhD in Aerospace Engineering from Texas A&M University in 2016, where she was advised by Prof. John Junkins. She is a recipient of the Distinguished Graduate Student Award for Excellence in Research at Texas A&M University.