Cymer Center for Control Systems and Dynamics

# Recent Advances in Multi-Resolution Approximation for Modeling and Control

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Some recent developments from approximation theory are overviewed which enable piecewise-continuous, multi-resolution approximation in N-dimensional spaces. Global-Local Orthogonal Mapping (GLOMAP) enables piecewise approximations with a new family of orthogonal functions. The orthogonal approximations are constructed, centered at the $2^N$ vertices of a hypercube and such that the domains of validity of the adjacent $2^N$ approximations overlap in the local hypercube formed by their centers of validity. These overlapping approximations are averaged with special partition of unity weight functions that guarantee global piecewise continuity (of prescribed order) as well as satisfaction of boundary conditions. Also presented are several generalizations of Lagrange's Implicit Function Theorem; it is shown how to blend local Taylor series approximations of the implicit function using partition of unity weight functions, to construct a piecewise continuous global family of local approximations. This lecture introduces essential ideas and explores a few applications in nonlinear dynamics and controls. In particular, we show how to use these approximation methods to construct extremal field map approximations for optimal hybrid propulsion interplanetary trajectories, and for stochastic systems, to establish a new approach to solve the Fokker Planck equation for the probability density function characterizing the evolution of uncertain nonlinear system dynamics. In the latter application, some problems heretofore amenable only to solution on high performance super computers are now being solved using personal computers. While Bellman's curse of dimensionality remains a challenge, this seminar shows significant progress is being made. The ideas presented are applicable to a large family of problems.

**Dr. Junkins** (PhD, UCLA, 1969) holds the Royce E. Wisenbaker Chair and also the title of Regent's Professor. Prior to joining Texas A&M in 1985, he held academic appointments at the University of Virginia and at Virginia Tech. He has also held positions at McDonnell Douglas Astronautics Company, NASA Marshall Space Flight Center and has consulted with over two dozen laboratories. Dr. Junkins is the author of over 370 publications, including 6 textbooks and several patents. He is a prolific mentor, having directed over 100 graduate students and post-doctoral researchers. Over a third of his 38 PhD students are on leading faculties worldwide and have given rise to three generations of PhDs. His former students constitute a significant school of thought in industry and academia. Dr. Junkins is a member of the National Academy of Engineering and the International Academy of Astronautics; he is a Fellow of the American Institute of Aeronautics and Astronautics (AIAA) and the American Astronautical Society. He has received a dozen national and international honors, including the AIAA Pendray Aerospace Literature Award and the International Astronautical Federation's Frank Malina Medal.