TEXAS TECH UNIVERSITY
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Novel Techniques for Space Situational Awareness: Combining Multi-Node Space-Based Observations with High Fidelity Computations

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Abstract: In this talk, research thrusts highlighting the analytical and computational work taking place at the Astrodynamics and Space Robotics Laboratory (ASRL) at the University of Central Florida will be presented in the area of space situational awareness.

First, A new method for inertial orbit estimation of an object, either known or unknown, adaptable to a network of observation satellites is presented. The observation satellites would only require a monocular camera for line of sight measurements. Total system observability is analyzed and the instantaneous observability (per node) is used to remove "bad" measurements from the system. The measurement model is used in an extended Kalman filter framework and the measurement noise nonlinear transformation is addressed.

Second, a Taylor series based technique, Analytic Continuation is implemented to develop a method for the computation of the gravity and drag perturbed State Transition Matrix (STM) incorporating adaptive time steps and expansion order. Four types of orbits, LEO, MEO, GTO and HEO, are presented and the simulations are run for 10 orbit periods.

The accuracy of the STM is evaluated via RMS error for the unperturbed cases, symplectic check for the gravity perturbed cases and error propagation for the gravity and drag perturbed orbits. The results are compared against analytical and high order numerical solvers (ODE45, ODE113 and ODE87) in terms of accuracy. The results show that the method maintains double-precision accuracy for all test cases and 1-2 orders of magnitude improvement in linear prediction results compared to ODE87. The present approach is simple, adaptive and can readily be expanded to compute the full spherical harmonics gravity perturbations as well as the higher order state transition tensors.

Finally, a general overview of the research taking place at our lab that includes other current as well as future research thrusts will be presented.

Bio: Tarek A. Elgohary is an assistant professor at the mechanical and aerospace engineering department at the University of Central Florida. Before that, he was a postdoctoral research associate at Texas A&M Aerospace Engineering. He received his BS in Mechanical Engineering from the American University in Cairo and his Master and PhD in Aerospace Engineering from Texas A&M University. He was a visiting scholar in the department of mechanical and aerospace engineering at the University of California, Irvine in 2014/2015. He received the Texas A&M aerospace graduate student fellowship in 2012 and the Heep fellowship from the Texas A&M institute for advanced study in 2013. His research interests are developing analytical & computational techniques for nonlinear systems, optimal control and two-point boundary value problems and uncertainty quantification in Astrodynamics.