ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control - Part 3 (9)

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SPACECRAFT ACTUATOR ALIGNMENT DETERMINATION THROUGH NULL MOTION EXCITATION

Abstract

Current methods of system identification (sys ID) inject random or sinusoidal signals into the system and obtain feedback to learn system parameters. In general these methods do not consider the signals property of learning convergence or its effects to the overall system. In addition, the richness of a random signal is reduced when passed through the actuator acting as a low-pass filter. Furthermore, both of the random and sinusoidal signals do not consider the effect of the motion on the controlling body (e.g., movement of the tool-point for a robot manipulator with respect to its joint motion, movement of the entire satellite with respect to its attitude actuators, movement of the Mars rovers with respect to its wheels).

A guidance law is developed here to support direct nonlinear adaptive control algorithms to satisfy persistence of excitation (PE) for learning system parameters (specifically spacecraft actuator misalignments) without inducing large perturbations to the controllable body. This approach exploits the null-motion solutions of over-actuated systems and provides a gradient-based method to identify the direction along the null space to excite for fast local convergence of the learned parameters. The effort hypothesizes that a family of null-motion solutions from the guidance law will cause small but measurable perturbations upon the controllable body. Also, the motion of the actuators has the ability of being of larger amplitude and frequency than would be available structurally for the controllable body states, which makes it valid for some current satellite programs. The outcome of this research will be a guidance law structured for a direct nonlinear adaptive control law for a family over-actuated systems with determination of actuator alignment using the null-space combined with the proposed gradient-based method (assuming known mass and environment properties).