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Nonlinear lyapunov control improved by an extended least squares adaptive feed forward controller and enhanced luenberger observer

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Three adaptive approaches for a non-linear feed-forward controller are combined with two physics-inspired sinusoidal trajectory planners in a spacecraft attitude control model for large slew maneuvers. The basis of the model is a space based satellite sensor which has suffered an unwanted collision where the inertial matrix of the craft is no longer similar to the originally measured inertial matrix. This causes a large inherent error in the feedforward control needed for system maneuvers due to the mismatch of expected dynamics. Trajectory generation, feedforward control, feedback control, filters, observers, and system stability are discussed in relation to the non-linear dynamics under simulation. The adaptive feed-forward controllers discussed include a proportional-derivative (PD) adaptive controller, a Recursive Least Square (RLS) Method, and an Extended Least Squares (ELS) Method. Mean control effort stayed relatively constant between configurations. The controller configuration with ELS feedforward, PID feed-back, and an extended sinusoidal trajectory outperformed the baseline adaptive controller. Mean error was decreased by 23.4%, error standard deviation by 34.0%, and maximum error by 33.0% from a similar case using RLS adaptation. This improvement is entirely based on a need to correct for un-modeled or mis-modeled dynamics. This scenario occurs in actual operation during spacecraft launch, collisions with debris, or can be caused by fuel slosh or loose components.

Biography

Matthew A Cooper received his MS in Electrical Engineering and his MS in Aeronautical Engineering from the Air Force Institute of Technology through the Autonomy and Navigation Technology (ANT) Center, and his BS in Electrical Engineering from the Pennsylvania State University. He has worked as a Telecommunications Specialist for the Defense Information Systems Agency (DISA), as an Electrical Systems Integration Engineer for BAE Systems in the M109A6 Paladin Upgrade Program, as a Geospatial Intelligence Project Engineer at the National Air and Space Intelligence Center (NASIC), and most recently as a Program Manager for the Air Force Research Laboratory (AFRL) involving R&D of high power laser sources. His research interests include adaptive control, nonlinear control, digital holography, traditional and hollow-core fiber lasers, and autonomous systems.

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