IAF ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (2) (4)

Author: Dr. Martina Mammarella
National Research Council, Rome, Italy

Dr. Fabrizio Dabbene
Consiglio Nazionale delle Ricerche (CNR), Italy
Prof. Carlo Novara
Politecnico di Torino, Italy
Dr. Elisabetta Punta
Italy
Dr. Claudio Celiberti
Sitael Spa, Italy
Dr. Pierpaolo Pergola
Sitael Spa, Italy
Dr. Tommaso Misuri
Sitael Spa, Italy

SLIDING MODE AND PREDICTIVE ROBUST CONTROL TECHNIQUES FOR MULTI-PURPOSE PLATFORMS BASED ON HIGH-POWER ELECTRIC PROPULSION

Abstract

The advancement of robotics and autonomous systems will be central to the transition of space missions from current geocentric architectures to self-sustainable, independent systems. Every future mission architecture will heavily rely on the ability to autonomously rendezvous and mating multiple elements in space. For these critical capabilities to become routine, considerably more reliable rendezvous capability must be employed. The peculiarity of these missions is the large number of constraints and the stringent safety requirements to be fulfilled to ensure mission success. The complexity of these maneuvers and the consequent probability of failure drastically increase when the satellite exploits electric thrusters as main propulsion system. Indeed, on the one hand electric propulsion represents a valid alternative to chemical one due to their lower propellant demand. On the other hand their peculiarity of generating low level of thrust at very high-power demand limits their actuation/control capabilities. The direct consequences are longer missions and considerably slower maneuvers. In this framework, advanced robust techniques as model predictive control (MPC) and sliding mode control (SMC) could represent an effective solution to properly handle operational, safety and mechanical constraints also in the presence of uncertainty and disturbance sources. Moreover, the capability to predict the evolution of the scenario also in the presence of obstacles, would allow to properly re-determine optimal trajectory in real-time without aborting the rendezvous maneuver. This inherent feature would allow to prove the exploitability of electric propelled satellite for rendezvous maneuvers not only with unmanned target, e.g. debris, but also with inhabited stations. In this paper, a SMC-MPC guidance and control strategy is proposed, tailored to: i) ensure robust constraint satisfaction also in the presence of environmental disturbance acting on the system; ii) comply with the limitations and peculiarities of the propulsion subsystem; iii) guarantee collision avoidance recalculating in real-time alternative low-thrust trajectories to avoid obstacles/debris during the maneuver; and iv) be compatible with and real-time implementation. The proposed approach is based on a SMC scheme for attitude tracking and a tube-based robust MPC for orbital tracking, while an event-

triggered MPC scheme is exploited for the collision avoidance task, allowing the real-time re-generation of the optimal trajectory in the presence of obstacles.