World Academy of Science, Engineering and Technology
International Journal of Electrical and Computer Engineering
Vol:13, No:11, 2019

Hardware-In-The-Loop Relative Motion Control: Theory, Simulation and Experimentation

Authors : O. B. Iskender, K. V. Ling, V. Dubanchet, L. Simonini

Abstract : This paper presents a Guidance and Control (G&C) strategy to address spacecraft maneuvering problem for future Rendezvous and Docking (RVD) missions. The proposed strategy allows safe and propellant efficient trajectories for space servicing missions including tasks such as approaching, inspecting and capturing. This work provides the validation test results of the G&C laws using a Hardware-In-the-Loop (HIL) setup with two robotic mockups representing the chaser and the target spacecraft. Through this paper, the challenges of the relative motion control in space are first summarized, and in particular, the constraints imposed by the mission, spacecraft and, onboard processing capabilities. Second, the proposed algorithm is introduced by presenting the formulation of constrained Model Predictive Control (MPC) to optimize the fuel consumption and explicitly handle the physical and geometric constraints in the system, e.g. thruster or Line-Of-Sight (LOS) constraints. Additionally, the coupling between translational motion and rotational motion is addressed via dual quaternion based kinematic description and accordingly explained. The resulting convex optimization problem allows real-time implementation capability based on a detailed discussion on the computational time requirements and the obtained results with respect to the onboard computer and future trends of space processors capabilities. Finally, the performance of the algorithm is presented in the scope of a potential future mission and of the available equipment. The results also cover a comparison between the proposed algorithms with Linear–quadratic regulator (LQR) based control law to highlight the clear advantages of the MPC formulation.

Keywords : autonomous vehicles, embedded optimization, real-time experiment, rendezvous and docking, space robotics
Conference Title : ICSEAS 2019 : International Conference on Space Engineering and Automous Systems
Conference Location : Singapore, Singapore
Conference Dates : November 18-19, 2019