DEVELOPPEMENT DE LOI DE PILOTAGE POUR LE SERVICE EN ORBITE

Soutenance de thèse – KRAIEM Sofiane
16 mai 2022 à 13h00
Salle des thèses, Isae-Supaero, 10 Avenue Edouard Belin, Toulouse

Devant le jury composé de :

Benoit Clément	ENSTA Bretagne – Brest	Rapporteur
David Henry	Université de Bordeaux	Rapporteur
Paolo Gasbarri	University of Rome La Sapienza	Examinateur
Hélène Evain	CNES	Examinateur
Vincent Dubanchet	Thales Aliena Space	Examinateur
Jurek Sasiadek	Carleton University	Examinateur
Mathieu Rognant	ONERA-DTIS	Directeur de thèse
Yves Brière	ISAE-SupAéro	Co-Directeur de thèse

Résumé

Space manipulators allow to respond to a variety of problems in future space exploitation and exploration such as on-orbit deployment, active debris removal or servicing operations. However, a difficulty to autonomously control space manipulator systems arise with large and light structures presenting flexible behavior. Flexible dynamics remain a challenging topic as its modeling may present a first difficulty while the different coupling with the manipulator may deteriorate the control quality.
This thesis addresses design and control problems related to autonomous space manipulator equipped with kinetic moment exchange devices for spacecraft rotation control when dealing with system internal disturbances, model uncertainties and measurement errors. The modeling of rigid-flexible dynamics of a multi-body system remains a challenging task, and a first contribution of this work is a generic modeling tool to derive kinematic and dynamic of a rotation-free-floating Space Manipulator System (SMS) with flexible appendages.
This analysis led to the main contribution of this thesis, namely the implementation and the design of such control scheme for On-Orbit Servicing operations. Thanks to the model, proposed control include the non-measurable states (i.e flexibility) in the system decoupling and linearization, and the steering laws established are based on Nonlinear Dynamic Inversion (NDI) framework where observers are introduced to improve the quality of linearization. In a first implementation an Extended State Observer (ESO) have been involved to estimate flexible dynamics. Then, in a second time, the modeling uncertainties and measurement errors have been handled by the addition of a Nonlinear Disturbance Observer (NDO).
Inter-dependencies between observers and control dynamics have motivated a simultaneous computation of their gains to improve system stability and control performances. This point has been achieved by the resolution of Linear Matrix Inequalities (LMI) to guarantee stability with an appropriate Lyapunov function. In order to highlight the interest of the proposed scheme and validate our approach in a realistic environment, extensive tests of an on-orbit space telescope assembly use-case have been performed on a high-fidelity simulator.

Mots clés

Robotics, Space manipulator, Extended state observer, Nonlinear Dynamic Inversion, Disturbance compensation, Linear Matrix Inequality

Lien visio : https://rdv.onera.fr/Soutenance_SKRAIEM