Online policy iteration ADP-based control of post-capture combined spacecraft without inertia identifications

Liu, Jingyi; Guo, Jian; Gill, Eberhard

Publication date
2022

Document Version
Final published version

Published in
Proceedings of the International Astronautical Congress, IAC

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (1)

Author: Mrs. Jingyi Liu
Delft University of Technology (TU Delft), The Netherlands

Dr. Jian Guo
Delft University of Technology (TU Delft), The Netherlands
Prof. Eberhard Gill
Delft University of Technology, The Netherlands

ONLINE POLICY ITERATION ADP-BASED CONTROL OF POST-CAPTURE COMBINED SPACECRAFT WITHOUT INERTIA IDENTIFICATIONS

Abstract

Using robotic arms to capture space debris is a promising method in active debris removal. Since most space debris is uncooperative target, uncertainties exist in the inertial parameters of the combined spacecraft after target capture. In this paper, a novel attitude takeover control method based on adaptive dynamic programming is investigated for the post-capture combined spacecraft with unknown external disturbances. The controller requires no inertial information. Firstly, the Lagrange-form dynamic model of combined spacecraft is linearized. After linearization, the unknown inertia of the combined spacecraft is separated from the Lagrange equation, which is the pre-requisite of the design of the adaptive controller. Then, an adaptive dynamic inversion controller is designed to realize initial stabilization of the combined spacecraft. Lastly, a control method based on policy-iteration adaptive dynamic programming is introduced as the supplementary controller to improve the robustness of the attitude control in the presence of unknown external disturbances. The adaptive dynamic inversion controller provides with the initial stabilization for policy iteration. Two neural networks are used to approximate the cost function and the optimal control. A novel learning rule is developed to simultaneously update the weight of the two neural networks. Simulation results show that, in the presence of unknown time-varying disturbances, the weight of the two neural networks update responsively, which means that the two neural networks can learn to adapt to the disturbances. Compared with the single adaptive dynamic inversion controller, the combined controller is more robust with the supplementary ADP-based controller. Compared with traditional action-dependent heuristic dynamic programming (ADHDP) control, of which the weights of the two networks are updated sequentially, faster convergence of the two neural networks is achieved simultaneously, which can guarantee the application efficiency of learning-based control method in combined spacecraft attitude control.